2004 ESC Meeting

RULES AND REQUIREMENTS

OF THE

Underwriters' Association

OF THE

Middle Department

FOR THE INSTALLATION OF

WIRING AND APPARATUS

FOR

LIGHT, HEAT AND POWER.

Adopted August 31, 1897.

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Las Vegas, Nevada

2004 ELECTRICAL SAFETY COMMITTEE MEETING

Monday, July 26, 2004

1:00 – 3:00 - **Planning for 2005 Electrical Safety Meeting**

Tuesday, July27, 2004

7:30 – 8:00 - **Registration**
8:00 – 8:10 – **Introductions**
8:10 – 8:20 – **Welcome – WAPA** - Bill Marsh
8:20 – 8:30 – **Welcome - NNSA** – Terry Wallace
8:30 – 9:15 - **Electrical Incidents In DOE** – Frank Russo
9:15 – 10:00 – **Think Outside the Box -- Developing Innovative Approaches to Electrical Issues** - Scott Gilmore
10:00 – 10:30 - Break
10:30 – 11:00 - **Survey of Local Codes and Standards**- Chuck Monasmith
11:00 – 12:30 - Lunch
12:30 – 2:00 – **Recognizing Electrical Fire and Shock Hazards** - Joe Tedesco
2:00 – 2:30 - Break
2:30 – 4:00 - **NFPA 70-E Update** – Allen Bingham

Wednesday, July 28, 2004

8:00 – 9:00 – **Arc Flash Hazard Calculations - - Why? How? What's Next?** – Daniel Doan
9:00 – 10:00 – **Part 1 - Arc Hazards Involving High Noise Levels and Schrapnel** – Tom Neal
Part 2 – Arc Flash Product Improvements and Setting Up a Successful PPE Program – Tom Neal
10:00 – 10:30 - Break
10:30 – 11:00 – **OSHA** – Ray Nellor
11:00 – 12:30 - Lunch
12:30 – 1:30 – **Considerations in Selecting PPE for the Arc Thermal Hazard** – Roger Parry
1:30 – 2:00 - **Live Work and Electrical Safety** – Ed Hunt
2:00 – 2:30 - Break
2:30 – 4:00 – **Lessons Learned from Electrical Fatalities in Private Industry** – Mike Bahr

Thursday, July 29, 2004

8:00 – 9:00 – **Update on Latest Underground Detection Equipment** - Jerry Phillips
9:00 – 10:00 – **Electric Arc Update** - Hugh Hoagland
10:00 – 10:30 - Break
10:30 – 11:00 – **Electric Arc Update** - Hugh Hoagland
11:00 – 12:30 - Lunch
12:30 – 1:30 – **The Human Side of Electrical Safety: Why More Consideration is Needed to Protect Workers** – Richard DeBusk and Clyde Saunders
1:30 – 2:30 – **NFPA Update** – James Stallcup
2:30 – 3:00 – Break
3:00 – 3:30 – **Electrical Safety During Excavations** – James Luhring
3:30 – 4:00 – **Closure**

Electrical Safety Occurrences

Overview Of Nature, Causes, and Frequency

Frank Russo
Deputy Assistant Secretary
Office of Corporate Performance Assessment (EH-3)
July 27, 2004

Electrical Safety Awareness

- The Secretary declared 2004 as the "Year of Safety."
- Lessons learned from NASA's space shuttle accidents emphasize the recognition and correction of recurring near-misses as accident precursors.
- The majority of DOE's near misses are electrical.
- Average rate = 2 electrical occurrences per week.
- Electrical Safety Campaign
- The Deputy Secretary declared May as "DOE's Electrical Safety Month."

Frequency of Electrical Safety Occurrences

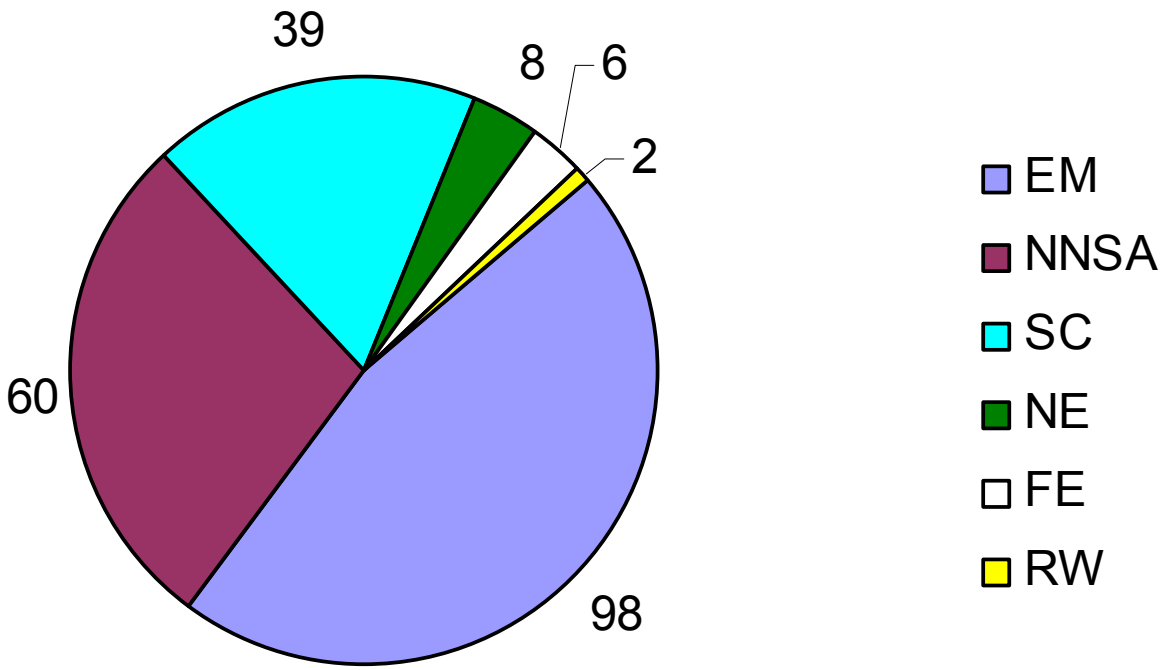
- **Analysis of ORPS reports from CY 2002 and 2003 found:**
  - **213 electrical safety occurrences (over two per week)**
  - **About ¾ of these categorized as near misses (to serious injury or death)**
  - **36 involved shocks to workers (required medical attention)**
  - **6 resulted in burns**

Frequency of Electrical Safety Occurrences (cont.)

- ORPS reports for January - May 2004 (5 months)
  - 56 electrical safety occurrences
  - Rate = 2.5 per week, slightly higher than 2002-2003
  - 9 involved shocks to workers
  - 1 resulted in burns (to eyes from arc flash)
- June 7, 2004 fatality at the Western Area Power Administration

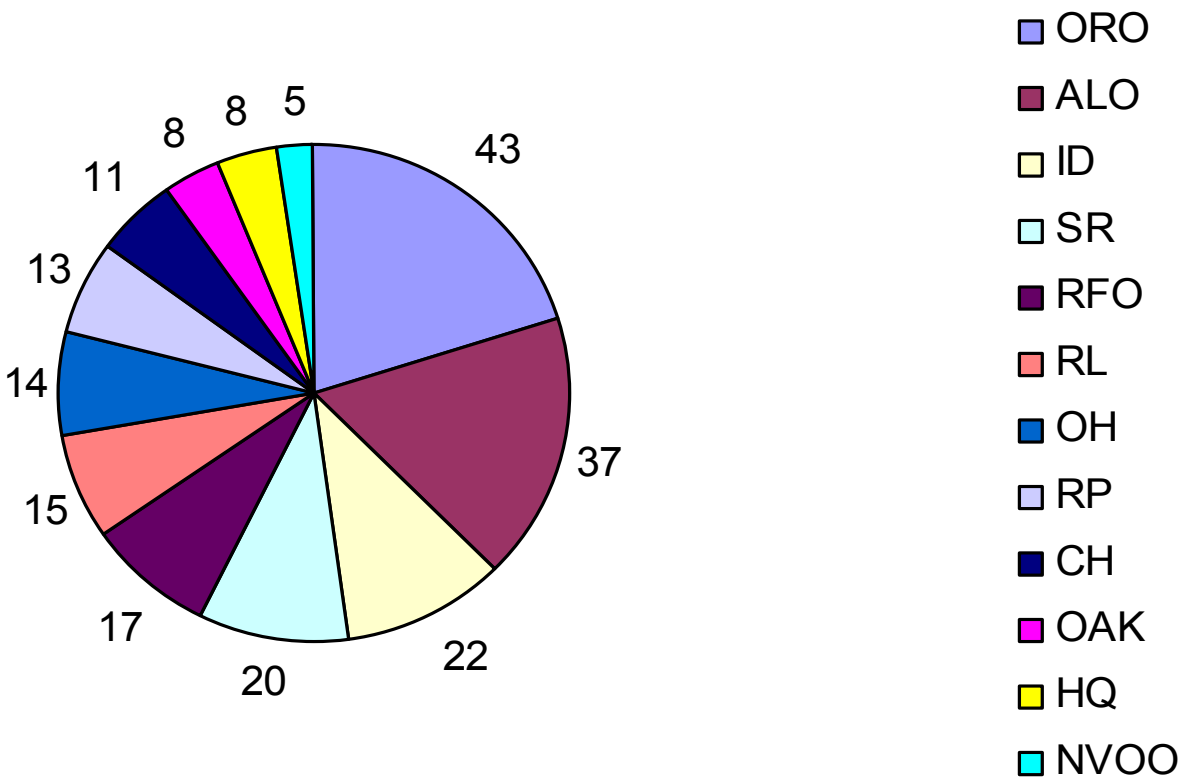
Distribution of Electrical Safety Occurrences

2002-2003 distribution by Secretarial Office



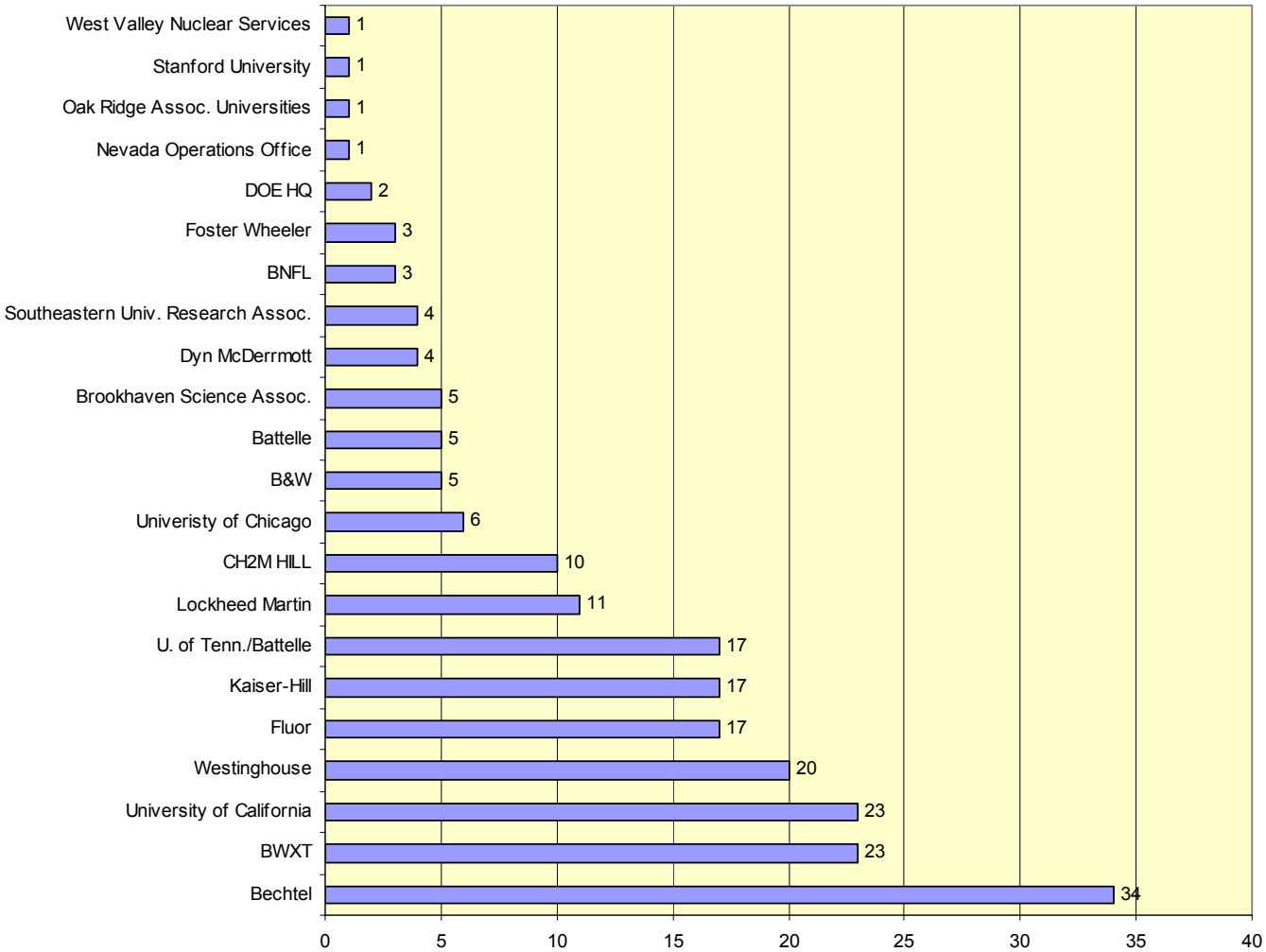
Distribution of Electrical Safety Occurrences

2002-2003 distribution by Field Office



Distribution of Electrical Safety Occurrences

Number of Electrical Events by Company (2002-2003)



Distribution of Electrical Safety Occurrences

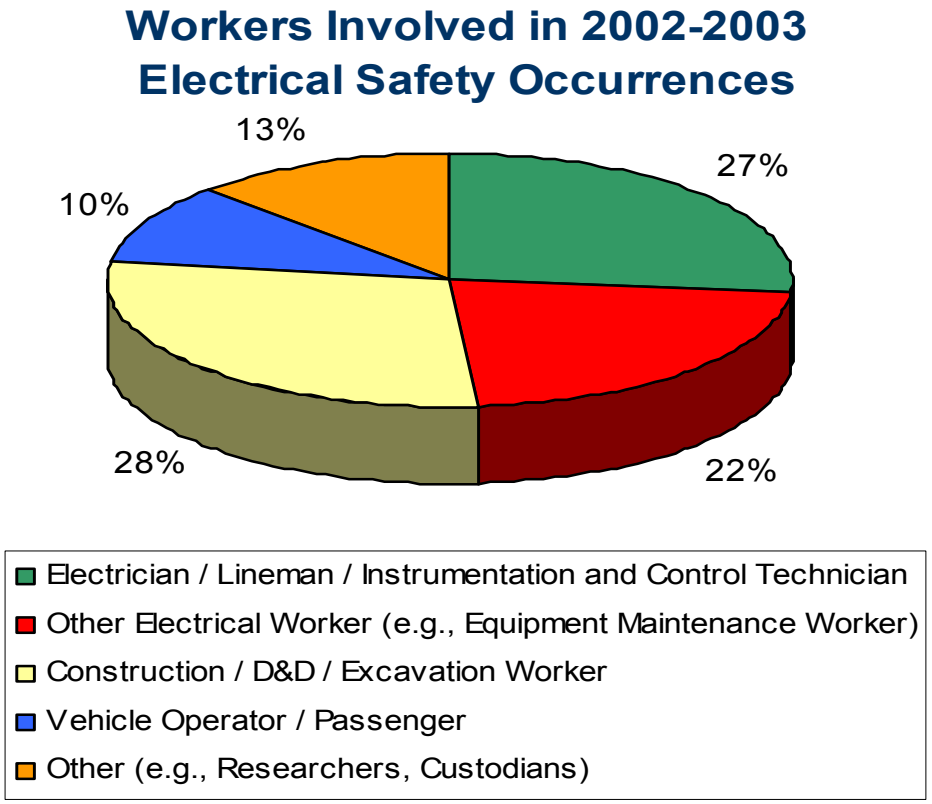
- **No obvious outliers***

- **Electrical occurrences happen DOE-wide**

*** Did not normalize and rank distributions.**

Distribution of Electrical Safety Occurrences

Half of workers involved were doing electrical work and the other half were not.



Nature of Electrical Occurrences

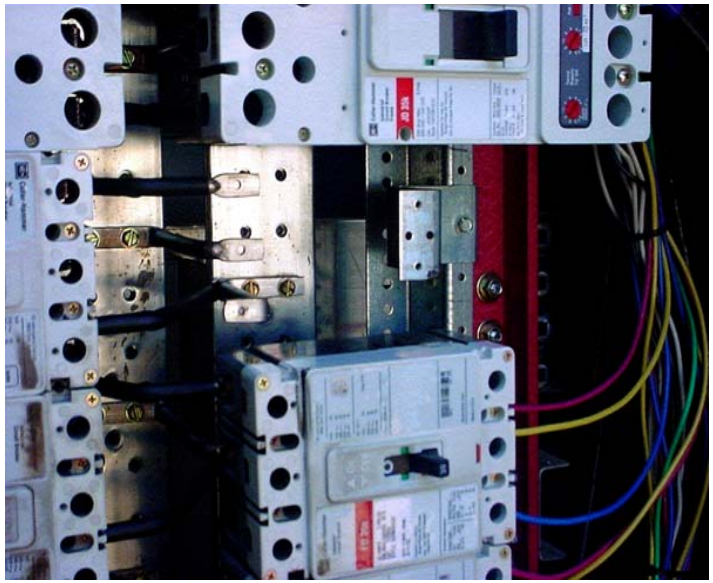
- **Analysis of 2002-2003 occurrences sorted these into four general types (Ref. April 2004 *Electrical Safety* Report):**

  - **Electrical work occurrences**
  - **Electrical intrusion occurrences**
  - **Vehicle/electrical occurrences**
  - **Other electrical occurrences**

Electrical Work Occurrences

- **Endanger electricians, linemen and trained electrical workers**

- **Most stem from personnel errors in planning or performing work with known electrical hazards**



Electrical Work Occurrences (cont.)

- **Causes:**
  - Electrical hazards and circuitry not fully understood
  - Lockout/tagout (LO/TO) mistakes and violations
  - Wiring mistakes
  - Failure to perform zero-energy checks
  - Working on energized equipment without authorization and PPE
- **Preventive Measures:**
  - Walk down job prior to performing work
  - Ensure independent verification of LO/TO
  - Reevaluate electrical conditions as D&D progresses
  - Always perform zero-energy checks
  - Stop work if unexpected electrical hazards are found

Electrical Intrusion Occurrences

- **Endanger construction, D&D, and excavation workers**
- **Energized buried power lines severed during excavation**
- **Energized conduits and power lines drilled or cut into during construction or demolition**

Electrical Intrusion Occurrences (cont.)

- **Causes:**
  - Inaccurate or missing as-built drawings
  - Work performed beyond limits of locator surveys
  - Procedure violations (e.g., machine-digging near known buried lines, failure to perform zero-energy checks during demolition)

- **Preventive Measures:**
  - Use reliable utility locator surveys
  - Clearly mark concealed wiring and equipment to be removed
  - Perform work soon after surveys and within limits of surveys
  - Hand excavate in close proximity to expected utility
  - Drill/dig no deeper then required
  - Use/wear appropriate PPE

Vehicle/Electrical Occurrences

- **Endanger truck, forklift, and heavy equipment drivers and passengers**

- **Vehicles contact and severe overhead utility and power lines, with voltage up to 13.8 kilovolts**

Vehicle/Electrical Occurrences (cont.)

- **Causes:**
  - **Missing or inadequate number of spotters**
  - **Poor communication between driver and spotters**
  - **Configuration of vehicle changed (e.g, boom or truck bed raised) during operation or upon exiting**
- **Preventive Measures:**
  - **An adequate number of spotters need to be assigned for the entire job, not just the site-entering phase**
  - **Ensure good communication between drivers and spotters**
  - **Job hazard analysis need to consider electrical hazards along all routes, and for raised configurations of vehicles**

Other Electrical Occurrences

- **Endanger researchers, custodians, lawn-mowing personnel, security guards, cafeteria workers, etc.**
- **Causes:**
  - **Miswired equipment, receptacles and plugs**
  - **Exposed hazards**
  - **In a few cases, researchers take risks with electrical hazards**
- **Preventive Measures:**
  - **Verify safe conditions when electrical work is completed.**
  - **Address hazards for routine work (e.g, extension cords on lawns to be mowed)**

Summary - Causes/Prevention of Electrical Occurrences

- **Most electrical occurrences are caused by:**
  - **inadequate work planning and hazard identification**
  - **LO/TO violations, shortcuts, lack of independent verification, and other Con Ops deficiencies**
  - **failure to perform zero energy checks and stop work**

- **Senior Management has been too tolerant of recurring electrical mishaps – greater accountability is warranted**

- **Most electrical occurrences are caused by unsafe acts or conditions, both of which are preventable.**

- **Thus, DOE can lower its rate of electrical incidents and near misses.**

Electrical Safety Campaign - Path Forward

- **Campaign goals are to significantly improve DOE's electrical safety performance by May 2005, and to share best practices.**

- **Secretarial Offices and sites are currently preparing performance baselines, metrics and actions**

- **The Electrical Safety Advisory Group will:**
  - **evaluate the causes of recurring electrical occurrence to address the question "Why are we not improving?"**
  - **review line-specific performance assessments**
  - **track and review 2004-2005 occurrences**
  - **recommend new strategies to change past unsafe behavior**

Electrical Safety Campaign - Path Forward (cont.)

- Site briefings to Secretarial Office by September 2004
- Quarterly status reports to Deputy Secretary and Under Secretaries – next one due in July
- Identification and dissemination of best practices
- Corporate evaluation/summary of DOE's electrical safety performance due for Deputy Secretary in May 2005

New Electrical Safety Reports

- **DOE Operating Experience and Lessons Learned Report: *Electrical Safety,* April 2004 (http://www.eh.doe.gov/paa/reports.html)**
- **Just-In-Time reports (http://www.eh.doe.gov/paa/jit.html)**
  - ***Electrical Demolition***
  - ***Excavation Incidents***
  - ***Penetration Activities***
  - ***Energized Work***
  - ***Electrical Wiring Errors***
  - ***Vehicles and Overhead Lines***
  - **In preparation: *Electrical Lockout/Tagout* (3 separate reports)**

Other Electrical Safety Resources

- ***DOE Electrical Safety Handbook,*** **January 1998**

  (http://tis.eh.doe.gov/techstds/standard/hdbk1092/hdbk1092.pdf)

- ***A Review of Electrical Intrusion Events at the Department of Energy: 2000-2001*****, June 2002**
  (http://www.eh.doe.gov/paa/reports/elec_intrusionfinal.pdf)

- **DOE/EH-0557, *Electrical Safety*, Issue No. 98-01, October 1998 (http://tis.eh.doe.gov/publications/safetynotices/sn98-01.html)**

- **Other Electrical Safety Campaign documents (http://www.eh.doe.gov/hottopics.html)**

The Deputy Secretary of Energy
Washington, DC 20585

April 23, 2004

MEMORANDUM FOR DISTRIBUTION

FROM: KYLE E. McSLARROW

SUBJECT: Electrical Safety Month

I have designated May 2004 as Electrical Safety Month for the Department of Energy (DOE).

I continue to be concerned about the number of serious electrical occurrences and want DOE and contractor managers to take necessary steps to improve performance in this area. I have given the Office of Environment, Safety and Health corporate responsibility to carryout DOE-wide improvement efforts in conjunction with Headquarters Program Secretarial Officers.

If you have any questions, please contact Mr. Frank Russo at (301) 903-8008 or Mr. Frank Tooper at (202) 586-1772.

Printed with soy ink on recycled paper

DEPARTMENT OF ENERGY
ELECTRICAL SAFETY

Operating Experience and
Lessons Learned Report

U.S. Department of Energy
Office of Corporate Performance Assessment

April 2004

www.eh.doe.gov/paa

Electrical Near Misses Continue to Occur

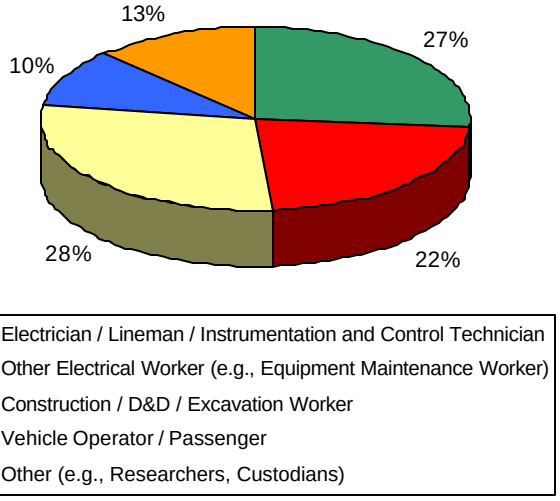
Electrical safety occurrences are the most frequently reported near miss events across the DOE complex, and thus pose the greatest risk to workers. In 2002 and 2003, electrical safety occurrences were reported at a rate of two per week, with three-quarters of them categorized as near misses (to serious injury or death). Thirty-five of the electrical occurrences in this 2-year period involved shocks to workers; six resulted in electrical burns.

An analysis of the electrical occurrences in 2002 and 2003 showed that about 50 percent involved electrical work performed by electricians and other electrical workers who install, remove, or maintain electrical equipment or components. DOE's non-mandatory *Electrical Safety Handbook* (DOE-HDBK-1092-98) addresses these activities. While deviating from recommendations in the handbook and other electrical standards often contributed to occurrences involving electrical work, the root causes largely stemmed from basic conduct of operations deficiencies involving work planning, lockout/tagout, and configuration management. (The *Electrical Safety Handbook* is available at http://tis.eh.doe.gov/techstds/standard/hdbk1092/hdbk1092.pdf.)

Electrical occurrences involving non-electrical workers (e.g., construction workers and vehicle drivers) comprised the remaining occurrences. In many cases, the electrical hazards in these occurrences resulted from errors and deviations previously made by electrical workers. Non-electrical workers are protected by general regulations, such as OSHA rules for construction, excavation, and vehicle safety. These workers' activities are not directly addressed in the DOE *Electrical Safety Handbook.*

The purpose of this report is to describe commonly made electrical safety errors and identify lessons learned and specific actions that should be taken to prevent similar occurrences.

Workers Involved in 2002-2003 Electrical Safety Occurrences



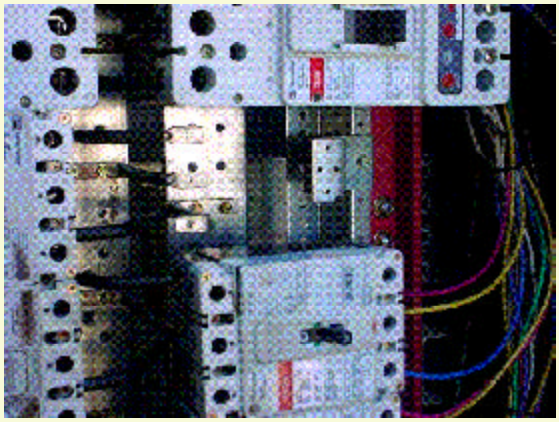
Electrical Work Near Misses

Qualified electricians, linemen, instrumentation and control, electrical or electronic technicians, and trained operations or maintenance workers who installed, removed, and maintained electrical equipment were involved in electrical near misses in 2002-2003. All such electrical

Electrician Burned by Electric Arc Flash in 2002

A journeyman electrician was replacing a 20-amp circuit breaker with a 60-amp breaker in an energized 480-volt, 1,600-amp distribution panel when an electric arc flash occurred. He received minor flash burns on his forearm and neck. In violation of procedures, the electrician tried to minimize downtime to the facility by mounting the replacement breaker without de-energizing the panel. He then planned to isolate the panel with a lockout/tagout before attaching the breaker to the bus bar and load side connectors. However, as he was attaching a mounting screw, his screwdriver slipped, made contact between a breaker lug and a grounded mounting plate, and created the arc flash.

Damaged screwdriver



Arc-flash damage to distribution panel

workers are expected to know how to protect themselves from the electrical hazards they will be exposed to while performing their tasks.

About three-quarters of the electrical work occurrences were caused by either personnel errors (e.g., procedure violations or "inattention to detail") or work control weaknesses. Common personnel errors included working on energized equipment or circuits without authorization or personal protective equipment, wiring mistakes coupled with failure to verify safe-energy conditions, and leaving unsafe conditions (e.g., improper grounding). The most effective safety barrier against electrical energy is to de-energize the source and control it with a lockout/tagout process. However, mistakes in establishing and clearing lockout/tagouts were common work control problems.

Lockout/Tagout Requirements

- OSHA regulation 29 CFR 1910.147(a)(3)(i) states: "This section requires employers to establish a program and utilize procedures for affixing appropriate lockout devices or tagout devices to energy isolating devices, and to otherwise disable machines or equipment to prevent unexpected energization, start up or release of stored energy in order to prevent injury to employees."

- OSHA regulation 29 CFR 1926.333(b)(2) *Lockout and Tagging*, states: "While any employee is exposed to contact with parts of fixed electric equipment or circuits which have been de-energized, the circuits energizing the parts shall be locked out or tagged or both in accordance with the requirements of this paragraph."

Weakness in configuration management contributed to about one-fifth of the occurrences involving electrical work. In the

occurrences caused by configuration management problems, job planners were often at fault because they did not walk down the work site to verify as-built conditions and identify unexpected sources of energy. The lack of accurate drawings when needed to safely isolate electrical systems is also a continuing problem across the DOE complex. Changes in system configuration due to upgrades, construction work, and decommissioning work are not always incorporated into electrical drawings.

Measures to Prevent Electrical Work Occurrences

- Walk down the work site to (1) identify equipment to be worked on, (2) ensure that equipment to be isolated is clearly marked, (3) verify or modify drawings to reflect as-built conditions, and (4) identify additional hazards or other safety issues.
- For decommissioning work, re-evaluate electrical hazards as systems and equipment are dismantled and isolations are removed.
- Ensure that lockout/tagout procedures or work instructions include a zero-energy check to confirm the effectiveness of the lockout/tagout installation. Always perform a zero-energy check on the circuit to be worked, as well as on other nearby circuits and terminals. Perform these checks any time new areas or equipment are accessed.
- Upon completion of wiring work, check for proper voltages, phasing, and grounding.
- Use lockout/tagout processes if there is a possibility that work may be performed in close proximity to energized electrical conductors.

Electrician Shocked while Working on Energized Circuit in 2003

Electricians replacing light ballasts in a cafeteria worked on the energized, 277-volt circuits in accordance with past-approved practices. Due to the confined space, one electrician did not wear protective gloves. Design errors in the length of the wires connecting a ballast with a light fixture caused him to contact a live conductor. Current flowed into his finger and he sustained a burn on the little finger of his right hand, as well as exit burns on his right arm. After review of the incident, policies were changed to require de-energizing all circuits and securing them by lockout/tagout.

- Ensure that lockout/tagout procedures or work instructions include independent verification that the lockout/tagout has been correctly performed.
- Ensure that purchased electrical components and equipment are acceptance-tested before they are put into service.
- Work on energized circuits should be performed only after obtaining special approvals and developing job-specific safety controls.
- Always use electrical-rated personal protective equipment (e.g., insulated gloves and boots, ground-fault circuit interrupters, double-insulated tools, and rubber mats) when working on energized electrical circuits and equipment (required by 29 CFR 1910.335(a)(1)(i)).
- Stop work if an unanticipated electrical hazard or condition is encountered and seek appropriate assistance.

Electrical Intrusion Near Misses

Excavation, construction, and demolition workers are often placed at risk from

Discovered Energized Wires Cause Near Miss in 2003

While excavating a hole by hand in preparation for installing a counter-balance for a door, an equipment operator discovered unmarked wires in a corroded, broken conduit. The excavation work was stopped and a utilities locator reviewed the drawings, but could not find conduit and wires in that location. An electrician was dispatched to the site, and his initial checks of the wires did not reveal electric energy. The electrician then removed the cover from an electrical elbow in a nearby facility and discovered abandoned wires. To verify that the wires in the excavation were the same as the abandoned wires, the electrician had the equipment operator tug on the wires to see if they moved. Instead, an arc occurred in the conduit as the operator pulled the wires.

accidental intrusion into energized electrical lines. Electrical intrusion events include accidental contact with underground utilities during excavation and penetration of embedded or concealed utilities within structures such as walls, floors, and ceilings. The workers involved are generally not trained as electrical workers.

Such events can cause injuries ranging from minor electrical shocks to severe burns to electrocution, especially when personal protective equipment is not used. Intrusion events also incur monetary costs for the repair of breached wires and conduits and for the lost time associated with repairs, power outages, and delays in tasks and facility missions. Causes include inaccurate as-built drawings, procedure noncompliance (e.g., not hand digging as required), blind penetrations, lack of zero energy checks, and inadequate component marking during electrical conduit demolition. The range of voltages involved 120 volts through 13.8 kilovolts.

The review of these events was divided into two types: excavation and cutting/drilling.

Excavation Near Misses

Excavations that struck buried electrical utilities were reported at a frequency of once per month during 2002 and 2003, with the majority occurring during construction. The workforce in these events consisted primarily of subcontractors, and the voltage they were exposed to was typically 480 volts. The method of excavation during these occurrences was almost evenly divided between machine excavation and hand excavation. Machine excavation involved backhoes, trackhoes, loaders, and excavators;

Grader Snags an Energized 120-Volt Line in 2003

Construction workers assigned to install an erosion control fence decided to use a grader with a ripper blade when their ditch-witch could not penetrate the soil. They accidentally snagged an underground line running from an onsite utility pole to a facility building. The equipment operator checked the breaker for the line and it was tripped. Environmental restoration personnel have always used guidance known as the "1-foot rule" (i.e., if the soil will be penetrated less than 12 inches an excavation permit locating underground utilities is not necessary). The fence installation required only 6 to 8 inches penetration. What was not considered was that past activity at the site could have lowered the surface level in relation to the depth that underground utilities were originally installed. Workers did not realize that they should have stopped work and informed management when the electrical cable was discovered. When the excavation permit was requested, the area was not clearly defined. Facilities personnel thought there were no utilities in the area specified and wrote "no underground utilities" on the front of the permit.

while hand excavation involved jackhammers, shovels, picks, digging bars, and posthole diggers. Although equipment operators were generally separated by distance from the immediate hazard (e.g., inside their vehicles), laborers were in close proximity to the electrical hazard because they were using hand tools.

In many of the occurrences, inadequate as-built drawings or lack of drawings was cited as a major causal factor. Other causal factors included failing to use locating equipment or not complying with the requirements of the excavation permits, (e.g., hand-digging within 5 feet of buried electrical line in order to save time). Also, there were some occurrences in which using survey equipment did not provide a positive locate. Only one worker received an electrical shock while attempting to locate utilities.

Laborers Exposed to Energized 480-Volt Cable Damaged by a Trackhoe in 2003

An excavation operator cut into an energized 480-volt cable while digging a building foundation with a trackhoe, causing a circuit breaker to trip. The damage to the cable was not apparent because it was still buried. Laborers entered the excavation to hand dig and uncover the cable but they did not know that someone had reset the circuit breaker and reenergized the cable. Heat given off by the damaged cable caused water in the excavation to release steam to the atmosphere. The laborers immediately stopped work. Investigators determined that the subcontractor site superintendent knew of the requirement to de-energize and lock out the cable, and did not. He knowingly sent workers into the excavation to hand dig around an energized cable in violation of procedures. Exposure to the energized cable could have been avoided if the circuit had been locked out.

Cut electrical conduit

In several occurrences, workers assumed that utilities were abandoned or de-energized, or they assumed the wrong depth or direction of buried utilities. In addition, many workers failed to initiate a lockout/tagout when they knew there were utilities in the area.

Cutting and Drilling Near Misses

Cutting and drilling into energized electrical lines have been reported at a frequency of once per month. The majority of these occurrences happened during construction and facility demolition. The workforce in these occurrences primarily involved employees of the prime contractor, and

Craftsman Cuts into Energized Electric Line while Removing Conduit in 2003

A demolition craftsman was removing conduit with a reciprocating saw and cut into an energized 110-volt line. The work control document explicitly required verification that the line was either de-energized and air-gapped or covered by a lockout/tagout. Investigators learned that, based on work performed a month before, the craftsman assumed that electricians had de-energized the circuit. He also failed to request a zero-energy check or complete a thorough walkdown to verify that all electrical service was air-gapped.

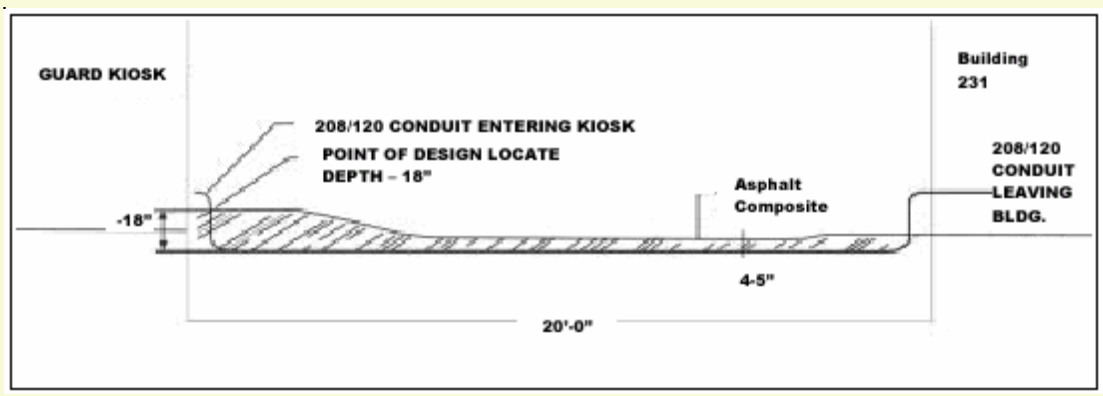
typically they were exposed to 120 volts. These occurrences involved drilling into structures (blind penetrations) or cutting conduit using hand tools. This is significant because hand tools place the worker in close proximity to the hazard (i.e., energized source).

The majority of the events occurred while cutting conduit with saws or core drilling with electric drills. One worker received an electrical shock while cutting conduit with a hydraulic shear. For facilities that are undergoing closeout and demolition, a typical activity involves the removal of electrical conduit. In many cases, some electrical systems may need to remain energized (such as lighting circuits) while other conduit and electrical systems are being removed. This can present a challenge to ensure that circuits are properly marked and de-energized.

In many of the occurrences, workers failed to perform a zero-energy check before cutting into conduit containing energized electrical conductors. In some instances they just assumed the circuit was de-energized. In other cases, workers failed to lockout the energy source, failed to verify the circuit was air-gapped (separated from an electrical source), or failed to verify (physically trace) the power source. Other causes included inadequately marked conduit or confusing markings on conduit to be removed. Also, in some of the excavation events, workers wrongly assumed the location or direction of concealed electrical lines.

Laborers Cutting Asphalt Severed a Buried Energized Line in 2003

Laborers performing an asphalt saw-cutting operation partially severed an underground 208/120-volt electrical conduit. The location of the conduit was correctly marked on the surface of the asphalt, but the depth was assumed to be 18 inches. The actual depth of the conduit below the surface was determined to be only 4 inches. However, because of the short distance of available conduit (20 feet), the depth locator on the locating equipment had a high degree of inaccuracy. The manufacturer specifications for the locating equipment stated that distances less than 50 feet would not produce accurate depths on buried utilities and air coupling might result. The workers expected to find the conduit at 18-24 inches below grade based on Laboratory experience and the design locate survey which showed a depth of 18 inches at the guard kiosk. Investigators concluded that Ground Penetrating Radar (GPR) might have provided additional information. GPR is used for locations when the locator believes the readings are suspect or if the length of conduit/pipe identified is less than 50 feet in length. The GPR readings compensate for the uncertainty in locating equipment when determining depth.



Common Aspects of Electrical Intrusion Events

Electrical intrusion-type events typically involve non-electrical workers (e.g., equipment operators, laborers), performing non-electrical work who may not have any type of electrical safety training or expectation that an electrical hazard exists. Fortunately there were no serious injuries from such events in 2002 and 2003. Stop-work authority was almost universally used when unexpected conditions were encountered and in some cases, workers used personal protective equipment.

Determining the precise location of buried and embedded utility lines is an industry-wide problem. As-built drawings should not be relied upon as the only source for locating underground or embedded utilities, particularly if the accuracy of the drawings is suspect. Scanning and survey equipment has been used successful to locate electrical lines. However the technology has limitations that need to be understood; for example, embedded conduit and rebar have similar reflective properties. The general uncertainties surrounding the existence and precise location of these utilities demand special planning and execution of any excavation, penetration, or cutting activity.

The potential hazard of energized utilities should be identified and controlled through the implementation of physical and administrative barriers to help prevent accidents. Barriers include appropriately rated personal protective equipment, lockout/tagout, and verification of zero energy.

OSHA requirements and prevention measures generally apply to all types of intrusion events, whether they were caused during excavation, penetration, or demolition work. OSHA defines concealed wiring as wiring rendered inaccessible by the structure or finish of the building. Wires in raceways are considered concealed, even though they may become accessible by withdrawing them. As shown in the text box, OSHA sets safety standards for employee protection.

OSHA Requirements to Prevent Electrical Intrusion

- 29 CFR 1926.416(a)(2) states: "In work areas where the exact location of underground electric power lines is unknown, employees using jack-hammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves."
- 29 CFR 1926.416(a)(3) states: " Before work is begun the employer shall ascertain by inquiry or direct observation, or by instruments, whether any part of an energized electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact with the electric power circuit. The employer shall post and maintain proper warning signs where such a circuit exists. The employer shall advise employees of the location of such lines, the hazards involved, and the protective measures to be taken."
- 29 CFR 1926.651(b)(1) states: "The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation."
- 29 CFR 1926.651(b)(2) states: "Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation."

Measures to Prevent Electrical Intrusion Occurrences

- Mark all concealed electrical wiring when located.
- Drill pilot holes and penetrate no deeper than is required for the job.
- Check drill holes frequently for obstructive material, such as wire fragments or rebar.
- Always wear personal protective equipment.
- Clearly mark components that are to be removed and establish boundaries and hold points for zero energy verification when performing demolition work.
- Conduct source checks for energy near the work, and not just at "known" energy sources.
- Exercise "stop work authority" if unanticipated conditions are encountered.
- Use appropriate personal protective equipment that has proper electrical ratings.
- Standardize methods for identification and location of concealed or buried electrical utilities.
- M&O contractors should share information such as locator data, drawings, and permit information with subcontractors performing the work.
- Analyze the specific work activity and do not just base hazards controls on established standards and work practices.
- Perform excavation and penetration work in a timely manner following surveys and marking of locations. Markings can deteriorate over time, and conditions can change.
- Employ utility locator services or use the latest survey technology available.
- Hand-excavate in close proximity to the expected location of the utility rather using excavation equipment.
- Re-evaluate hazards analysis processes and associated controls for excavation and electrical penetration-type work.
- Place marking tape or electronic markers above newly installed utilities or excavated utilities to aid in future identification.

Vehicle Near Misses

Vehicles strike overhead electrical power lines and other electrical sources within the DOE complex almost monthly. Such occurrences in 2002 and 2003 involved dump trucks, cement trucks, tractor-trailers, front-loaders, trackhoes, excavators, and forklifts snagging overhead utility lines with voltages ranging between 120 volts and 13.8 kilovolts. In a few occurrences, the vehicles hit utility poles, guy wires, messenger cables and communication lines, and this damage indirectly severed the power lines. In some cases, live power lines fell onto the vehicles,

In 2002, excavator boom contacted 13.8 kv overhead power line

Gravel Truck Contacts 13.8 kV Electrical Transmission Line in 2002

The driver of a gravel-hauling truck had just completed a gravel dump at a DOE site and was lowering the truck bed when the bed came in contact with an energized 13.8 kilovolt transmission line. The truck served as an electrical ground, blowing one tire and scorching two others and causing a small grass fire. The driver was aware of the transmission line but had guessed incorrectly that he had enough clearance to lower the truck bed. His escort had not been trained as a spotter. Although the escort expressed concern over the clearances, he did not stop the operation. The driver and escort were fortunate not to have been injured or killed.

placing the drivers and passengers at risk from electrical shock.

In many of the occurrences, the vehicle drivers knew of the electrical hazards and initially passed them safely — most likely giving them a false sense of confidence. When the drivers' tasks changed the vehicles' profiles (e.g., by raising a truck bed, boom, fifth wheel, or forklift mast), they neglected to consider this effect and subsequently snagged the utility lines on their exit trips.

In one occurrence, a road was initially closed to truck traffic, and overhead lines were hung to an allowed lower clearance. When the road was opened to truck traffic, site personnel neglected to raise the overhead lines to the height required for trucks (see requirements text box). Subsequently, a concrete truck that had unloaded and was exiting snagged four overhead lines, breaking three utility poles. In recent years, a similar occurrence resulted from raising a roadbed at a construction site but neglecting to raise the lines crossing overhead.

In several occurrences, spotters were used as required by OSHA regulations (see text box) but the spotters lost communication with the drivers or a single spotter was insufficient to see all the hazards. In other cases, the spotters were effective only initially and either left or became diverted before the snagging occurred.

Vehicle / Overhead Line Requirements

- OSHA regulation 29 CFR 1910.333(c)(3)(III)(A) states: "Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized lines shall be operated so that a clearance of 10 feet is maintained."

- OSHA regulation 29 CFR 1910.550(A)(15)(IV) states: "A person shall be designated to observe clearance of the equipment and give timely warning for all operations where it is difficult for the operator to maintain the desired clearance by visual means."

- Institute of Electrical and Electronic Engineers *Standards for Overhead Conductor Clearances*, Part 2, Table 232-1 requires that for roads and other areas subject to truck traffic, the maximum sag for wires, conductors and cables is a height of 15.5 feet.

Measures to Prevent Vehicle/Electrical Occurrences

- Job hazard analyses for tasks involving vehicles need to include all work areas and travel routes to identify overhead electrical hazards and to address appropriate requirements for vehicle clearances and an adequate number of spotters.

- Job hazard analyses should also consider the possibility of changed vehicle profiles

and load configurations, such as raised truck beds, the shifting of masts and booms, and the increased heights of vehicles after unloading.

- Spotters assigned to transports need to be dedicated for the whole job, including exiting.

- Drivers must be trained to stay in communication with spotters and to be aware of the effect of changed vehicle and load configurations on clearances.

- Guy wires, utility poles and overhead lines need to be marked if not clearly visible to drivers and spotters.

Other Electrical Near Misses

A significant percentage of the electrical safety occurrences could not be categorized in the work activities discussed above. For example, researchers, security guards, cafeteria workers and custodians experienced electrical shocks. In those occurrences, incorrectly installed or deteriorated wires, plugs, receptacles and improper grounding were the direct causes. In two separate occurrences, workers mowing grass cut unmarked electrical extension cords used to power outside monitors.

In most of these "other occurrences," the people affected were unaware of (or inadequately trained for) the electrical hazards to which they were exposed. Similar to the occurrences discussed above involving construction and excavation workers, the workers were placed at risk by the previous actions (or lack of action) of others.

Student Researcher Receives Electrical Shock During 2002

A student researcher performing an experiment was shocked when he touched the metal edge of a fume hood with one hand while the other hand held a stainless steel inspection mirror in contact with a metal reactor. An ungrounded cartridge heater inside the reactor had failed and produced the shock. Such failures occurred occasionally with this type of equipment; however, unlike other hoods at the facility, this one did not have a ground fault circuit interrupter (GFCI) device to prevent shocks. A corrective action was to install a GFCI device.

Safety Responsibilities

When performing tasks that may involve electrical hazards, roles and responsibilities should be clearly defined, understood, and reviewed before beginning work. In addition, all workers must be aware of their responsibility to stop work whenever the safety of the operation is questionable. The following questions, based on lessons learned from recent electrical occurrences, pertain to the safety responsibilities of all workers.

- **Managers**

  - Has sufficient rigor been applied to hazards analyses, work planning, and equipment inspection in work environments involving multiple tiers of contractor and subcontractor personnel?

  - Have site-specific electrical requirements been provided to subcontractors for implementation?

  - Are workers aware of their stop-work authority, and do they understand how to invoke it?

  - Do qualified supervisors oversee personnel in training and briefings?

  - Do electrical safety committees meet regularly and address emerging electrical safety issues, benchmark other site's programs, share best

practices, self-assess their safety programs, and explore new technologies for locating concealed utilities and electrical hazards?

- **Work Planners**
  - Are accurate drawings and equipment identification used? Have the drawings and equipment identification been verified by walk-downs and subject matter experts to ensure they reflect as-built configuration?
  - Have walk-downs also been performed to check for potential hazards and anything that could interfere with the performance of work?
  - Are measures taken to locate undetected buried and embedded power lines?
  - Are workers assigned personal protective equipment suitable for planned tasks and for potentially undetected electrical hazards?
  - Have an adequate number of spotters been assigned to tasks involving vehicles, and are they dedicated until the vehicles complete their task or leave the site?
- **Supervisors**
  - Do pre-job briefings identify all electrical safety hazards?
  - Do workers understand their tasks and the potential hazards involved?
  - Do all workers understand that improvising is prohibited?
  - Do workers understand their responsibility to stop work when problems emerge instead of taking ad-hoc compensatory measures?
  - Are steps taken to ensure that electrical systems are not left in an unsafe condition at shift turnover?
  - Are barriers (e.g., lockout/tagouts) adequate and in place?
  - Are spotters and vehicle/equipment operators able to communicate verbally and visually?
  - Have workers passed on relevant and accurate information regarding electrical safety issues to co-workers and supervisors?
  - Do workers focus their attention on the safety-significance of the task and remain alert to the potential impact from distractions?
  - Do workers approach each task with a questioning attitude, thinking through the steps and key decision points before acting?
  - Are post-job briefings held to critique performance and identify improvements?
- **Electrical Workers**
  - Do the components, procedures, tools, personal protective equipment, and resources provided satisfy the requirements of the planned tasks?
  - Have checks been made to verify that electrical circuits/equipment are not left in an unsafe condition?
  - Are electrical equipment/component responses (e.g., voltage measurements) those that are expected?
  - Is equipment de-energized before being serviced or maintained?
  - Are correct shielding and insulating materials and tools being used when

working on electrical equipment/circuits?

  - Has approval been given to work in energized equipment/circuits?

  - Are procedures for working near energized equipment being followed or used?

- **Non-Electrical Workers**

  - Have steps been taken to identify and mitigate electrical hazards?

  - Has personal protective equipment been provided or have other measures been taken to prevent risks from undetected energized circuits during drilling, cutting and excavation?

- **Vehicle Drivers/Equipment Operators**

  - Have overhead power lines and sources and their heights been identified for the travel routes to be taken?

  - Will any operation of the vehicle place it, its mechanical equipment, or its load within 10 feet of overhead lines, utility poles, or supporting guy wires?

  - Are dedicated spotters provided for all travel routes and for all work activities? (If not, why not?)

- **Spotters**

  - Are there sufficient spotters to detect all hazards and communicate them to the vehicle drivers/equipment operators?

  - Have steps been taken to ensure communication with vehicle drivers/equipment operators?

Office of Corporate Performance Assessment

The Office of Environment, Safety and Health, Office of Corporate Performance Assessment (EH-3) has two overarching responsibilities. These are to review existing operational safety data streams to determine if significant safety vulnerabilities exist, and to provide information in support of DOE decision making. Significant safety vulnerabilities are communicated to appropriate management so that intervention can take place before serious safety issues or events arise.

Although safety is difficult to measure in terms of accidents prevented, existing safety operational data identify safety vulnerabilities both at a site-level and complex-wide level. The Office of Performance Assessment and Analysis strives to provide line management with useful information to drive changes in the workplace that will continue to improve safety performance across DOE.

U.S. Department of Energy
Office of Corporate Performance Assessment

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Deficiencies in control and identification of electrical hazards during facility demolition have resulted in hazardous working conditions.

Events

Site/Facility: **NNSA Service Center**
Electrical Near Miss while Cutting Wire in Conduit -- Reference: **ORPS Report** ALO--GOAL-NNSASC-2004-0001
On February 10, 2004, a carpenter, performing demolition activities, came across a conduit that needed to be dissembled. While cutting a ground wire in the conduit with insulated pliers, he nicked an energized wire causing an electrical arc and a four-hour power outage. The carpenter was not injured

Important Points:	• **The carpenter did not verify that the wires inside the conduit were de-energized before cutting them.** • **The carpenter assumed that the wires de-energized and proceeded to disassemble the conduit.**

Site/Facility: **Mound Plant Tritium Facilities**
Demolition Worker Cuts Energized Circuit while Removing Conduit -- Reference: **ORPS Report** OH-MB-BWO-BWO01-2003-0004
On October 14, 2003, a demolition craftsman cut an energized 110-volt circuit while removing conduit with a double insulated reciprocating saw. The conduit contained numerous branches and only a cursory check was made for air-gapped circuits. Work control documents specifically required verification of zero energy or installation of a lockout/tagout if verification could not be performed.

Important Points:	• **The demolition worker failed to request a "meter check" to ensure a zero-energy condition existed.** • **The worker failed to complete a thorough walkdown of the area to verify that all conduit branches and runs were air-gapped and there was no potential for energy being fed from other sources.**
Contributors:	• **The demolition worker made assumptions about the task based on previous work experience on the same system months earlier. He assumed the lighting circuit was totally de-energized by an electrician when the light circuits were removed.**

Site/Facility: **Savannah River Site Fire Water Facility**
Worker Cuts Through Conduit and Observes Sparks -- Reference: **ORPS Report** SR--WSRC-SUD-2003-0006
On May 5, 2003, an electrical and instrumentation mechanic was cutting through conduit located below an electrical panel with a hacksaw when he saw sparks and detected smoke coming from the conduit. He immediately removed the hacksaw from the conduit. Subsequent engineering review of the electrical drawings for the system being demolished revealed unexpected voltage of 17 and 112 volts DC fed from a 2.3-kV cubicle.

Important Points:	• **A voltage check was not performed before cutting the conduit.** • **An inadequate review of the electrical drawings resulted in the failure ot identify an alternate source of voltage.**
Contributors:	• **There was no sign on the panel that indicated the presence of an alternate**

	energy source. • **Worker training on the requirement for conducting voltage checks was inadequate.**

Site/Facility: **Oak Ridge New Hydrofracture Facility**
Ironworker Cuts 120-Volt Service while Sectioning Conduit -- Reference: **ORPS Report** ORO--BJC-X10ENVRES-2003-0002
On May 1, 2003, an ironworker cut into an energized circuit while sectioning conduit with a hand-held hydraulic shear. He heard a pop and felt tingling in two fingers. Inspection by electricians after the incident revealed that the conduit was not to be removed and had been marked incorrectly for removal with spray paint.

Important Points:	• **The demolition subcontractor mistakenly marked an energized circuit from deactivation.** • **A zero-energy check was not performed before cutting as required.**
Contributors:	• **The demolition subcontractor Site Manager did not follow the detailed work instructions and allowed the laborer to cut electrical conduit wires without using a commercially available device (meter) to double check deactivation.** • **Work controls for the demolition task did not fully take into account the added risks of partial electrical isolation in the facility versus total isolation.**

Site/Facility: **Rocky Flats 371 D&D Project**
Electrician Cuts Conduit Containing Energized Wires -- Reference: **ORPS Report** RFO--KHLL-371OPS-2002-0039
On July 8, 2002, a demolition electrician cut a conduit containing an energized 120-volt line, causing a spark. The electrician was not injured. Although wires in the conduit were verified to be de-energized, a "T" connection in the conduit allowed an energized wire to enter at the connection and go undetected.

Important Points:	• **The electrician failed to fully inspect all branches of the conduit to ensure that all wires were verified to be de-energized.**
Contributors:	• **The electricians performing the demolition believed all wires in the conduit were identified and verified.** • **The electrician was not wearing dielectric gloves as specified in the procedure that required dielectric gloves, insulated tools and insulated mats.**

Important Considerations for Electrical Demolition (Lessons Learned)

- ☐ Who will verify that circuits have been properly isolated and de-energized?
- ☐ Have the circuits been air-gapped?
- ☐ Has a zero-energy check been performed to ensure that the circuits have been de-energized?
- ☐ Have all conduits/circuits been marked to indicate removal? Are cutting locations marked? Are there other circuits in the work area that must remain energized (including temporary power sources)?
- ☐ Are trained electricians performing the demolition? If not, are they available to support safe removal?
- ☐ Has the appropriate personal protective equipment been identified and provided to the workers?
- ☐ Have the workers and supervisors/foreman performed a walkdown of the electrical systems and conduit to verify the configuration and ensure the boundaries are understood?
- ☐ Has a pre-job briefing reviewed the scope of the job and the working boundaries? Have all parties involved in the work attended the briefing? Have all workers been reminded of their "stop work" responsibility.
- ☐ What actions are to be taken if the field configuration is not as anticipated by the work plan?

DEPARTMENT OF ENERGY
ELECTRICAL WIRING ERRORS
March 2004
Just-In-Time Operating Experience Report
U.S. Department of Energy
Office of Corporate Performance Assessment
www.eh.doe.gov/paa

Electrical wiring mistakes have resulted in electrical shocks and near misses.

Events

Site/Facility: **Hanford Waste Treatment Plant Construction Project**
Wiring Error Results in Electrical Shock -- Reference: **ORPS Report** RP--BNRP-RPPWTP-2003-0006
On December 3, 2003, a worker received an electrical shock when he grasped the leg of a 480-volt portable electrical heater with his right hand, while touching a metal tabletop with his left hand. The 3-phase, 4-wire, grounded plug on the heater had just been re-wired by an electrician, such that the ground wire was attached to a power prong and a hot wire was attached to the ground prong, energizing the heater housing with 277 volts.

Important Points:	• **The journeyman electrician did not perform a visual inspection or circuit check of the re-wired electrical plug before releasing it for use.**
Contributors:	• **It was not standard practice at the time of the incident for journeymen electricians to conduct circuit testing after wiring end caps.** • **Management did not have an assured grounding program or a program in place that required circuit testing following work on electrical equipment.**

Site/Facility: **Idaho National Engineering Laboratory - Test Reactor Area**
Near Miss - Improperly Wired Extension Cord -- Reference: **ORPS Report** ID--BBWI-TRA-2003-0008
On September 9, 2003, electricians discovered a miswired extension cord while troubleshooting a loss of power to a HEPA filter unit when a fuse blew. The extension cord had one of the phase wires connected to the plug case, resulting in a short to ground.

Important Points:	• **The electrician who fabricated the extension cord had never wired this type of connector before.**
Contributors:	• **The electrician failed to inform his supervisor of his inexperience and therefore, received no specific direction or oversight on how to wire the cord correctly.**

Site/Facility: **Los Alamos National Laboratory - Data Storage Project**
Miswired Welding Plug Results in Electrical Shock -- Reference: **ORPS Report** ALO-LA-LANL-NUCSAFGRDS-2003-0002
On May 27, 2003, a machinist received an electrical shock when he simultaneously touched a welding cart and another piece of equipment. A 480-volt plug on the cart was incorrectly wired (power lead and ground reversed) energizing the body of the cart. A journeyman electrician had installed the pin and sleeve plug as part of a modification to the welding cart.

Important Points:	• **The journeyman electrician, who installed the welder pin and sleeve cap, did not verify that the wiring was correct.**
Contributors:	• **Management's expectations of, and standards for, self-checks were not communicated to the electrician during the pre-job briefing, leaving an ambiguous process as to what was acceptable in verifying that work was performed correctly and left in a safe condition.** • **The task of verifying work was considered "skill of craft."**

Site/Facility: **Oak Ridge Spallation Neutron Source Construction Site**
Electrical Shock from Incorrectly Wired Receptacle -- Reference: **ORPS Report** ORO--ORNL-X10SNS-2003-0002
On May 27, 2003, an electrician received an electrical shock when he touched a metal component while working on a locked-out circuit. An incorrectly wired 120-volt receptacle in a communications cabinet had a ground wire connected to a power terminal and a hot wire connected to the ground terminal. In addition, a transformer had been rewired by a subcontractor electrician who failed to properly bond the neutral wire to ground allowing current to float between circuits. The floating current was carried through the improperly wired receptacle. .

Important Points:	• **The cabinet vendor had improperly wired the electrical outlet and an electrician incorrectly wired a transformer that together, created an unknown electrical hazard.**
Contributors:	• **The Quality Program failed to detect the improperly wired transformer because no inspection had been performed after the rewiring.** • **The communication cabinet was provided to the construction manager for installation without undergoing an acceptance inspection and approval.**

Site/Facility: **Lawrence Livermore National Laboratory - NIF Construction Site**
Improperly Wired Power Cord Results in Electrical Shock -- Reference: **ORPS Report** OAK--LLNL-LLNL-2002-0002
On January 15, 2002, an electrician received an electrical shock while plugging a supply cord into a short pigtail connected to a 208-volt power panel. Two experienced electricians had shortened the pigtail and accidentally switched the ground and a hot conductor in the connector at the end of the pigtail.

Important Points:	• **The wiring modification required a visual inspection for proper wiring and the electricians did not perform one.** • **The modification also required an assured grounding inspection on each pigtail using a voltage/continuity test instrument. Instead of testing each individual conductor for proper voltage, the electricians used an A/C Sensor Wand passed over the insulation of the pigtail, verifying only that it was energized and not correctly wired.**
Contributors:	• **The electricians were unaware of the requirements for an adequate assured grounding inspection.** • **The electricians did not have a procedure for assured grounding inspections.**

Important Considerations for Eliminating Wiring Errors (Lessons Learned)

- ☐ Is testing for proper wiring following maintenance or repair required or just assumed that it will be performed as skill-of-the-craft? Do work instructions typically include inspections and testing?
- ☐ Do workers know the configuration of the electrical wiring, plug, or circuit? Are terminals labeled and wires color coded to prevent confusion?
- ☐ What type of checks should be performed (e.g., voltage, continuity, phasing, polarity)?
- ☐ What are the proper methods for using test meters and instruments when checking for proper wiring? Are all workers trained and qualified to use these meters? How can you verify their qualifications?
- ☐ Is there an assured grounding program, in accordance with NEC (Section 305) and OSHA 29CFR1926.404(b)(1), at this facility/site? Have electrical workers (including subcontractors) been trained on the program and understand management's expectations?

The cited events are examples of electrical wiring errors that have occurred since January 2002.

DEPARTMENT OF ENERGY
ENERGIZED ELECTRICAL WORK

Just-In-Time Operating Experience Report
U.S. Department of Energy
Office of Corporate Performance Assessment

March 2004
www.eh.doe.gov/paa

Working near energized circuits has resulted in electrical near misses.

Events

Site/Facility: **Hanford Fast Flux Test Facility Project**
Instrument Technician Receives Electrical Shock while Removing Module -- Reference: **ORPS Report** RL--PHMC-FFTF-2004-0001
On January 26, 2004, an instrument technician received a shock while removing an electronic module from a control cabinet when his hand brushed against a 110-volt terminal while using a crescent wrench to remove a fastener. The technician had replaced another module the previous day as part of a troubleshooting effort to fix a heat trace control system, but that had not solved the problem. The technician knew of the energized circuits which were clearly marked.

Important Points:	• **No walkdown of the job site was conducted that could have identified an appropriate tool for the job and precautions to accomplish the task safely.** • **The technician did not use and personal protective equipment.**
Contributors:	• **The module was oriented differently than other similar modules he had worked on in other systems at the facility.** • **The module was located closer to the energized source than the module he had replaced the preceding day.** • **He self-imposed pressure to complete the job in twenty minutes to prevent the trace heat computer from timing out.**

Site/Facility: **Los Alamos National Laboratory - Data Storage Project**
Near Miss while Working Near Energized Panel -- Reference: **ORPS Report** ALO-LA-LANL-CMPTRDIV-2003-0001
On December 22, 2003, an electrician observed a subcontractor worker running a metal fish tape through a conduit toward an open junction box connected to fire alarm booster panel containing energized 120-volt terminals. Because the worker was alone, he used a block of wood at the end of the conduit at the junction box to prevent the fish tape from entering the fire alarm panel.

Important Points:	• **The worker did not recognize the hazards posed by running metal fish tape near energized equipment.** • **The worker was aware that a lockout was required before running wires into the panel (which he planned to do); however he did not consider a lockout for running the metal tape.**
Contributors:	• **The activity hazards analysis did not address the use of fish tapes.** • **The panel was not de-energized and locked out.**

Site/Facility: **Sandia National Laboratory - Albuquerque**
Electrical Subcontractor Causes Short Circuit -- Reference: **ORPS Report** ALO-KO-SNL-1000-2003-0007
On October 10, 2003, a journeyman electrician accidentally pinched a 120-volt energized conductor while using a knockout cutting device to cut a 3-inch access hole in a distribution panel to attach a new service raceway conduit. There was no injury but the ground fault opened a circuit breaker resulting in a power outage.

Important Points:	• **The electrician assumed the panel could not be de-energized and he chose to work energized because he believed he could perform the work safely.** • **The work in the panel was designated to be performed during a planned power outage per the hazard control identified in the activity hazard analysis.**
Contributors:	• **The construction safety plan included a procedure for obtaining a permit to authorize work on energized electrical circuitry.** • **The electrician did not understand the protocol for requesting a permit.** • **The protocol did not clearly define "energized work."**

Site/Facility: **Strategic Petroleum Reserves - Bryan Mound Site**
Electrical Near Miss while Pulling Power Cables into Raceway -- Reference: **ORPS Report** HQ--SPR-BM-2002-0001
On March 15, 2002, an electrician unbolted a metal cubicle separation panel and left it hanging in a motor control center to facilitate routing cables. While pulling cable, the panel inadvertently contacted an energized 480-volt bus bar, causing a fault and circuit breaker to open. The panel was attached to a Lexan barrier that protects the bus bars and when it was removed, it created an opening that exposed personnel and equipment to the energized bus bars.

Important Points:	• **De-energizing the bus and applying a lockout was considered not necessary because the Lexan barrier would provide protection (if left in place).** • **The panel should not have been removed while energized.**
Contributors:	• **The electrician should not have been allowed to take a shortcut by leaving the panel hanging by wires from an attached terminal strip for a 110-volt space heater.**

Important Considerations for Energized Electrical Work (Lessons Learned)

- ☐ Has safety training been provided to personnel who work on energized equipment/circuits?
- ☐ How will all circuits near the work be verified as de-energized or energized? Who will perform that verification?
- ☐ What are the proper methods for using test meters in checking for energized circuits? Are all workers trained and qualified to use these meters? How can you verify their qualifications?
- ☐ Has authorization been given to work on or near energized equipment? Who can authorize this work? Below what voltage can work be performed without authorization? Does a two-man rule apply when working energized?
- ☐ Is the correct personal protective equipment (PPE) being used when working energized?
- ☐ What protective equipment is required (e.g., shielding, insulating materials, tools)? How can you verify that the equipment is in good condition and appropriate for the work? Has the protective equipment been issued and being used?
- ☐ What should be done if procedures or work instructions have not adequately addressed electrical safety?
- ☐ What actions must be taken if before any work is performed that is not clearly specified in the work package?
- ☐ Do all workers know the configuration of the electrical equipment and completely understand the limits of the work scope?
- ☐ Has the prejob briefing reviewed the scope of the work, equipment train and equipment location? Have all parties involved in the work attended the briefing?
- ☐ What first aid should be administered to a person who has been shocked?

Deficiencies in identification and control of electrical hazards during excavation have resulted in hazardous working conditions.

Events

Site/Facility: **Los Alamos National Laboratory**
Electrical Line Struck during Building Demolition -- Reference: **ORPS Report** ALO-LA-LANL-ADOADMIN-2004-0002
On March 1, 2004, a subcontractor trackhoe severed two 3-inch conduits while removing a foundation, causing a circuit breaker to trip. One conduit contained an energized 110/208-volt electrical line and the other contained a telecommunication line. The subcontractor did not know that the prime subcontractor had installed temporary utility lines to the building.

Important Points:	• **The subcontractor foreman and equipment operator believed all utilities for the building had been terminated.** • **The excavation permit was revalidated before starting the excavation but the utility locate crew did not revalidate the area containing the conduits.**
Contributors:	• **The utility locate crew was not notified that temporary utility lines had been installed by the prime subcontractor.** • **The prime subcontractor's person-in-charge was unaware of the installation of the temporary utility lines.**

Site/Facility: **Lawrence Livermore National Laboratory**
Electrical Conduit Near Miss Incident -- Reference: **ORPS Report** OAK--LLNL-LLNL-2003-0012
On March 28, 2003, a construction subcontractor hit and damaged a 2-inch rigid metal conduit containing an energized 480-volt circuit while excavating a concrete floor with a jackhammer. There was no indication of sparks or smoke, but a circuit breaker did trip.

Important Points:	• **The as-built drawings did not identify any conduit in the excavation area.** • **A ground-penetrating radar (GPR) scan conducted by a qualified subcontractor located the conduit but the GPR technology could not distinguish the conduit containing the electrical circuits from rebar.**
Contributors:	• **The metal conduit was on plane between two rebar mats. The conduit followed the rebar grid layout and provided no evidence that it was nothing more than rebar.**

Site/Facility: **Fermi National Accelerator Laboratory MINOS Construction Site**
Accidental Contact with an Energized 480-Volt Cable -- Reference: **ORPS Report** CH-BA-FNAL-FERMILAB-2003-0001
On March 6, 2003, an excavation operator cut into a known energized 480-volt cable while digging a building foundation with a trackhoe, causing a circuit breaker to trip. Laborers entered the excavation to hand dig and uncover the cable but they did not know that someone had re-closed the circuit breaker, reenergizing the cable. Water in the excavation was heated to steam by the damaged cable. The laborers immediately stopped work.

Important Point:	• **The subcontractor trackhoe operator knew the cable was energized and did not communicate that information to the laborers who were hand digging.**
Contributors:	• **Both the subcontractor site superintendent and the trackhoe operator knew the requirement to de-energize the cable and install a lockout/tagout before digging, but failed to do so.** • **The circuit was re-energized before determining why the circuit breaker had tripped.**

Site/Facility: **Fermi National Accelerator Laboratory NuMI Construction Project**
Energized Power Cable Severed during Excavation -- Reference: **ORPS Report** CH-BA-FNAL-FERMILAB-2002-0005
On December 12, 2002, an excavation subcontractor damaged a conduit containing 480-volt energized conductors while trenching to uncover a water line for demolition. After exposing the damaged conduit, an electrical subcontractor checked the conductors with a proximity detector and believing them to be de-energized, cut the conductors with a ratchet-type hand cutter, causing a ground fault and arc-flash.

Important Points:	• **The subcontractors did not verify the location of all utilities before excavation per the contract specifications. They failed to review the utility drawing before and after uncovering the conduit.** • **The subcontractors did not follow their lockout/tagout procedures before cutting the conductors.**
Contributors:	• **The excavation hazard analysis did not list any specific hazards or safety procedures on how to handle unidentified utilities.** • **The subcontractor thought the electrical line was abandoned. He failed to notify the Fermi Lab Field Construction Coordinator of the unidentified electrical line as required.**

Important Considerations for Excavation Activities (Lessons Learned)

- ☐ Who will be responsible for performing utility locates (e.g., site/facility personnel, subcontractor, or local utility)?
- ☐ What type of survey instrument will be used? Is the instrument appropriate for the task? Does the user known the instrument's limitations and is he trained to correctly interpret the instrument's response?
- ☐ Have all available construction/as-built drawings been reviewed for buried utilities, piping systems, underground tanks?
- ☐ Has the excavation area been checked for buried hazards using survey equipment? Have detected hazards been identified and marked on the surface and documented before excavation begins? How long has it been since the survey was preformed? Is a revalidation necessary?
- ☐ Have identified electrical hazards been de-energized and locked-out? Who is responsible for ensuring that electrical hazards are de-energized?
- ☐ Is an excavation permit required? Has the permit been approved? Have the permit requirements been reviewed by all personnel (foreman, equipment operators, laborers) involved in the excavation?
- ☐ Has the pre-job briefing reviewed the permit requirements and scope of the excavation? Is hand digging required? What type of tools and equipment is required? What type of personal protective equipment is required?
- ☐ What actions should be taken if an unidentified obstruction is encountered (e.g., proceed or stop work and investigate)?
- ☐ Have as-built drawings been update to reflect the configuration of utilities that were found during the excavation? Has utility locating tape or devices been placed before closing the excavation?

DEPARTMENT OF ENERGY
BLIND PENETRATION INCIDENTS
March 2004
Just-In-Time Operating Experience Report
U.S. Department of Energy
Office of Corporate Performance Assessment
www.eh.doe.gov/paa

Deficiencies in work planning and hazards identification have resulted in electrical near misses when performing blind penetrations and core drilling.

Events

Site/Facility: **Hanford Energy Research Programs**
Electrical Near Miss during Core Drilling -- Reference: **ORPS Report** RL--PNNL-PNNLBOPER-2004-0001
On January 24, 2004, while core drilling into a concrete floor, the drill cut through an embedded conduit containing an energized 110-volt lighting circuit causing a circuit breaker to trip. Cutting water was found dripping out of a light fixture 15 feet from the work location. A scan showed embedded material consistent with rebar.

Important Points:	• **Workers believed that they were penetrating rebar because the scan indicated such and approval had been given to cut the rebar.**
Contributors:	• **The conduit was strapped to the rebar seen by the scan equipment.** • **Facility drawings were not complete as to location of the conduit.**

Site/Facility: **Lawrence Livermore National Laboratory National Ignition Facility**
Near Miss to Electrical Shock during Wall Penetration -- Reference: **ORPS Report** OAK--LLNL-LLNL-2003-0036
On October 14, 2003, a carpenter was installing a set of key boxes to a wall when a 3-inch screw made contact with a 277-volt bus bar in a 480/277-volt panel mounted on the other side of the wall, causing arcing inside the panel.

Important Points:	• **The pre-job walkdown of the job area failed to identify the electrical panel.** • **The 3-inch sheetrock screw was too long for the job.**
Contributors:	• **The carpenter believed an obstruction encountered (electrical panel) was a metal wall stud.** • **Proper work controls were in not place because management failed to adequately plan the work. There was no special permit or procedure required for penetration into walls.**

Site/Facility: **Oak Ridge National Laboratory Central Complex**
Electrical Near Miss during Concrete Penetration -- Reference: **ORPS Report** ORO--ORNL-X10CENTRAL-2003-0007
On July 30, 2003, a construction worker penetrated an embedded electrical conduit containing an energized 120-volt electrical line while hand drilling into a concrete beam to install pipe hanger inserts. The worker saw sparks from the drill hole. The conduit was struck after drilling approximately 1 inch into the beam.

Important Points:	• **Drawing reviews for embedded conduits were not performed.** • **No lockout/tagout was used.**
Contributors:	• **Conduits embedded in concrete structures are normally designed to be greater than 2" from the surface. The Excavation/Penetration Permit provides an exemption when drilling 2 inches or less into concrete. Drilling for this project was to depths of less than 2 inches, so no permit was required.**

Site/Facility: **North Las Vegas Pump House Facility**
Electrical Near Miss during Wall Penetration -- Reference: **ORPS Report** NVOO--BN-NLV-2003-0003
On June 24, 2003, construction personnel cut into energized 120-volt lighting circuit while drilling holes to install guardrails. The bit of the hammer drill penetrated a ½-inch conduit. Proper blind penetrations permits were in place and a Hilti Ferroscan FS10 instrument in the "Quickscan" mode was used to identify penetration locations.

Important Points:	• **The location of utilities was not marked on the structure as required.** • **The presence of the wiring was not identified by the Quickscan. The wiring was 6-inches within the wall, and a Quickscan observes to a depth of only 4 inches. The workers did not scan the interior side of the wall and did not know the instrument's depth limitations.**
Contributors:	• **Reliance was placed entirely on the Ferroscan to identify objects, including energized wiring; however, the instrument is designed to locate rebar and will not detect electrical cabling or conduit unless it contains sufficient iron (i.e., ferromagnetic detection).** • **Workers did not question instrument limitations because they frequently used it for this purpose and had not previously encountered wiring where no obstructions were identified.** • **No formal training was provided on the survey instrument because its use was considered skill-of-the-craft.**

Site/Facility: **Oak Ridge National Laboratory Nonreactor Nuclear Facilities**
Electrical Near Miss during Concrete Floor Penetration -- Reference: **ORPS Report** ORO--ORNL-X10NUCLEAR-2003-0009
On May 20, 2003, a construction pipefitter was drilling into the concrete floor to place an anchor to stabilize/support a condensate line when the drill penetrated a 110-volt electrical conduit and wiring to a nearby outlet. The penetration caused an arc and tripped a circuit breaker. The conduit was between 1½ and 2 inches from the surface of the floor.

Important Points:	• **It was believed that embedded conduits in concrete slabs and walls are normally greater than 2" from the surface.**
Contributors:	• **Facility as-built drawings show electrical conduits schematically rather than dimensionally.**

Important Considerations for Performing Blind Penetrations (Lessons Learned)

- ☐ Has the work area and surface to be penetrated been adequately inspected, potential hazards identified, and controls implemented? If full penetration of a floor, wall, or ceiling is to be performed, has the other side also been checked for hazards?
- ☐ Have all available construction/as-built drawings been reviewed for hidden hazards (e.g., electrical utilities) and obstructions (e.g., rebar)?
- ☐ Has the surface been checked for hidden hazards using survey equipment and are hazards marked?
- ☐ Have identified electrical hazards been de-energized and locked out? Who is responsible for ensuring that electrical hazards are de-energized?
- ☐ Is a penetration permit required? Has the permit been approved? Have the permit requirements been reviewed by all personnel involved in the penetration work? Are penetration depth limits established?
- ☐ Has appropriately rated personal protective equipment been identified and provided? Will an electrical drill stop be used if embedded rebar is expected?
- ☐ What actions should be taken if an obstruction is encountered (e.g., proceed or stop work and investigate)?

Deficiencies in planning and use of spotters contributed to vehicles striking overhead power lines.

Events

Site/Facility: **Los Alamos National Laboratory, Firing Sites and HE Lab**
Boom of Transported Crane Contacts 13.2-Kilovolt Power Line – Reference: **ORPS Report** ALO-LA-LANL-LANL-2004-0005
On February 26, 2004, the boom of a mobile crane being transported along a road struck a 13.2 kilovolt power line hung about 30 feet above the road. This caused arcing, separated all three lines of the three-phase distribution line, and damaged the crane's boom and cable. The crane operator had previously raised and lowered the boom to negotiate turns and had successfully passed under a 16-foot-high power line. However, the boom control mechanism subsequently malfunctioned and the operator's attempts to free it only raised the boom higher.

Important Point:	• **The transport had pilot vehicles leading and trailing the crane, but apparently their occupants did not serve as spotters.**
Contributors:	• **The crane operator was in a cab separate for the driver. The crane operator attempted to warn the driver of his raised boom by sounding a horn on the crane, but the driver did not stop in time.**

Site/Facility: **Savannah River Site, Site Utilities Department**
Dump Truck Bed Contacts 13.8-Kilovolt Transmission Line – Reference: **ORPS Report** SR--WSRC-SUD-2002-0009
On September 24, 2002, the driver of a gravel-hauling truck had just completed a gravel dump and was lowering the truck bed when the bed contacted an energized 13.8 kilovolt transmission line. The truck served as an electrical ground, blowing one tire and scorching two others, and causing a quarter-acre grass fire.

Important Point:	• **The driver was aware of the transmission line but had incorrectly guessed that there was enough clearance to lower the truck bed.**
Contributors:	• **The driver's escort was not trained as a spotter and did not serve as one.** • **Although the escort expressed concern over the clearances, he did not stop the operation.**

Site/Facility: **Brookhaven National Laboratory, former Hazardous Waste Management Facility**
Forklift Pulls Overhead Lines - Reference: **ORPS Report** CH-BH-BNL-BNL-2003-0013
On August 12, 2003, the mast of a forklift transporting a trailer-mounted generator caught and stretched a telephone cable hung underneath 208 volt electric power cables. This subsequently broke a backstay cable, tilted a utility pole about 15 degrees, and resulted in cables sagging within four feet of the road surface.

Important Point:	• **The spotters assigned to the evolution left during a temporary lull and the forklift driver decided to continue without them.**
Contributors:	• **The driver had focused his attention on his nearness to a building, and had overlooked the overhead lines.**

Site/Facility: **Oak Ridge, Y-12 Site**
Cement Truck Pulls Down Overhead Power Lines - Reference: **ORPS Report** ORO--BWXT-Y12CM-2002-0002
On November 12, 2002, a concrete truck had just completed a delivery of concrete to a construction site and was exiting the area when the receiving hopper portion of the truck snagged four overhead power lines. Before coming to a stop, the truck had pulled down the lines and broke three utility poles.

Important Point:	• **The access road had been closed to truck traffic when the overhead cables were hung. When the road was reopened for truck use, the hazard from low-hanging cables was not addressed.**
Contributors:	• **The hazard analysis checklist for the work site did not include overhead hazards at points of ingress and egress.**

Site/Facility: **Rocky Flats Environmental Technology Site, Non-plutonium Operations Area III**
Excavator Contacts 13.8-Kilovolt Power Line - Reference: **ORPS Report** RFO--KHLL-NONPUOPS3-2002-0002
On April 22, 2002, an excavator (track hoe) used for building demolition was being parked adjacent to a substation transformer. As is normal practice for this type of equipment with wide tracks, the operator extended the boom to assist in turning. The boom contacted a 13.8 kilovolt overhead power line more than 23 feet above the ground, causing arcing and tripping the substation feeder circuit breaker that powered the overhead line.

Important Point:	• **Although the operator knew of the overhead lines, he forgot about them when he turned the excavator.**
Contributors:	• **The job hazard analysis only addressed the need for spotters when backing heavy equipment, and not for other movements.** • **No area for parking idle heavy equipment was designated.**

Important Considerations for Vehicle Movements (Lessons Learned)

- ☐ Has pre-job planning and hazard analyses restricted vehicle travel and activities to only areas where overhead lines and other hazards have been addressed?
- ☐ Have overhead power lines and their heights been identified for the travel routes and activities to be taken?
- ☐ Will any operation of a vehicle place it, its mechanical equipment, or its load within 10 feet of overhead lines, utility poles, or supporting guy wires?
- ☐ As well as overhead power lines, are all guy wires, utility poles and communication lines clearly visible to drivers and spotters?
- ☐ Are there trained and dedicated spotters provided for all travel routes and for all work activities? (If not, why not?)
- ☐ Is the number of spotters assigned adequate to detect all hazards and communicate these to the vehicle drivers/equipment operators?
- ☐ Have steps been taken to ensure continuous communications between spotters and vehicle drivers/ operators?

OPERATING EXPERIENCE SUMMARY

Inside This Issue

- *Subcontractor worker removed from project for violating electrical safety controls 1*
- *Failure to wear protective eyewear results in serious eye injury 2*
- *Workers suffered significant hand injuries using the wrong tool for the job 4*
- *First-aid procedures not followed after acid burned through technician's glove 5*

U.S. Department of Energy

Office of Environment, Safety and Health

OE Summary 2004-04

February 23, 2004

The Office of Environment, Safety and Health, Office of Corporate Performance Assessment publishes the Operating Experience Summary to promote safety throughout the Department of Energy complex by encouraging the exchange of lessons-learned information among DOE facilities.

To issue the Summary in a timely manner, EH relies on preliminary information such as daily operations reports, notification reports, and conversations with cognizant facility or DOE field office staff. If you have additional pertinent information or identify inaccurate statements in the Summary, please bring this to the attention of Frank Russo, 301-903-8008, or Internet address Frank.Russo@eh.doe.gov, so we may issue a correction. If you have difficulty accessing the Summary on the Web (URL http://www.eh.doe.gov/paa), please contact the ES&H Information Center, (800) 473-4375, for assistance. We would like to hear from you regarding how we can make our products better and more useful. Please forward any comments to Frank.Russo@eh.doe.gov.

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EH PUBLISHES A REVIEW OF HOISTING AND RIGGING EVENTS

The Office of Environment, Safety and Health recently published *Department of Energy Hoisting and Rigging Events*. Hoisting and rigging activities typically involve the lifting, moving, and laying down of heavy loads. These tasks require careful planning, preparation, and implementation by a variety of individuals, including managers, work planners, supervisors, riggers, spotters, equipment operators, and maintenance personnel.

The purpose of this report is to describe the commonly made errors in these incidents and to identify the lessons learned and specific actions that should be taken to prevent similar incidents from recurring.

The report can be accessed at the URL **http://www.eh.doe.gov/HR_INPO_Style_FinalDraft_01-20-04.pdf**

EVENTS

1. ELECTRICIAN VIOLATES ELECTRICAL WORK SAFETY CONTROLS

On July 15, 2003, at the Hanford Solid Waste Storage and Disposal (SWSD) facility, a subcontractor electrician removed an air sampler without approval and without installing a lockout/tagout (LO/TO) on a circuit breaker to the air sampler cabinet. Subsequent investigation revealed that the electrician violated procedures for work release and hazardous energy control. Although no injuries resulted from this occurrence, working on electrical equipment without placing positive controls on the energy source can result in an electrical shock. (ORPS Report RL--PHMC-SOLIDWASTE-2003-0008; final report filed September 3, 2003)

Subcontractor workers were performing process upgrades in the SWSD facility, including removing some electrical panels and an air sampler cabinet. The site M&O contractor controlled the timing of subcontractor work by issuing work release forms on a weekly basis that authorized the work to be performed in that week. On July 15, 2003, the SWSD electrical supervisor and the subcontractor electrician walked down the air sampler cabinet power supply circuitry to establish boundaries for a planned LO/TO that was to be placed before electrical work was authorized. The air sampler was out of service, and the power supply circuit breaker was open.

After the walk-down, the electrician went back to the circuit breaker and confirmed that the circuit was de-energized using a voltmeter. He disconnected the remaining wires in the cabinet, pulled them out of the conduit that fed power to the air sampler, and removed the air sampler. That afternoon, his supervisor noticed that the air sampler had been removed and questioned the electrician. The electrician admitted removing the air sampler without a LO/TO, but stated that he knew the circuit was de-energized. The subcontractor supervisor confiscated the electrician's badge and removed him from the project. However, the supervisor did not report the incident to SWSD facility management, and the air sampler was replaced in its original position.

On July 17, 2003, while conducting a walkdown of the proposed LO/TO, the SWSD facility operations manager discovered that the air sampler had already been removed without a work release and without the installation of a LO/TO. He halted all subcontractor work in the facility. After investigators learned that the electrician's supervisor had not reported the incident, the facility operations manager confiscated the supervisor's badge and removed him from the project. He also suspended subcontractor work until all subcontractor personnel were briefed on the work release process and LO/TO requirements and a recovery plan was submitted.

Investigators identified multiple human errors in judgment by the electrician and his supervisor as the direct cause of this occurrence. They determined that the root cause was misuse (or in this case non-use) of established procedures for work control, hazardous energy control, and reporting of abnormal events.

SWSD management considered this a significant incident because the subcontractor agreed to comply with established safety programs, but did not. Because subcontractor personnel did not follow established procedures, SWSD facility management must depend on the subcontractor to successfully implement actions to prevent the occurrence of similar events.

Corrective actions taken as a result of this occurrence included the following.

- Require the subcontractor to submit an acceptable recovery plan before work restart.
- Implement a work control briefing for all new subcontractor personnel to address safety, work authorization, and event reporting requirements.
- Revise the work management plan to incorporate the new subcontractor briefing process.
- Revise the facility emergency hazards information control training program to incorporate the new subcontractor briefing process.

- Disseminate a lessons learned document on this occurrence.

A search of the ORPS database revealed several similar occurrences. On February 10, 2003, at the Nevada Operations Office, a subcontractor electrician received a burn to the little finger of his right hand and an exit burn on his right arm while replacing lighting ballasts. The electrician did not install a lockout/tagout on the 277-volt lighting circuit. (ORPS Report NVOO--GONV-GONV-2003-0001)

On July 15, 2002, at the Hanford Site, a journeyman electrician received minor flash burns to his forearm and neck while replacing a circuit breaker in an energized 480-volt, 1,600-amp distribution panel. While attaching a mounting screw, his screwdriver slipped and made contact with a breaker lug and a grounded mounting plate, creating an arc flash. To avoid facility down time, the electrician decided to install the breaker without de-energizing the panel, a blatant procedure violation. (ORPS Report RP--CHG-TANKFARM-2002-0075)

PROTECTING AGAINST WORKPLACE ELECTRICAL HAZARDS

- Use LO/TO processes if work may be performed in close proximity to energized conductors.
- Walk down the job site to establish the boundaries of a LO/TO application.
- Install a personal LO/TO on sources of hazardous energy associated with the work to be performed.
- Ensure that LO/TO procedures include independent verification of correct installation.
- Perform a zero-energy check before working on electrical components.
- Seek assurances that energy sources have been isolated, and then verify that this is so.
- Perform work on energized circuits only after obtaining special approvals and developing job-specific safety controls.
- Use the proper electrically rated personal protective equipment for the work to be performed.
- Stop work and seek assistance if unanticipated hazardous energy sources appear to be present in the workplace.

OSHA regulation 29 CFR 1910.147(a)(3)(i) states:

> This section requires employers to establish a program and utilize procedures for affixing appropriate lockout devices or tagout devices to energy isolating devices, and to otherwise disable machines or equipment to prevent unexpected energization, start up or release of stored energy in order to prevent injury to employees.

These events underscore the fact that violations of LO/TO procedures put workers at risk. A positive method of isolating the energy source from the item being worked on, such as installation of a LO/TO, is needed to ensure worker safety. Compliance with established electrical safety controls is not optional. Individual workers need to take responsibility for protecting themselves against electrical hazards in the workplace.

KEYWORDS: *Lockout/Tagout, intentional violation of safety controls, hazardous energy controls, work authorization, control of subcontractors*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls*

2. LACK OF EYE PROTECTION RESULTS IN SERIOUS EYE INJURY

On February 4, 2004, at the Hanford Tank Farms, a painter moving stanchions in a fabrication shop was struck in the eye by a steel washer on the end of a stanchion. The painter lost control of the 35-pound stanchion as he attempted to remove it from a saw horse, and the washer-end hit him, cutting his eye. The painter was not wearing eye protection, and his eye was severely damaged, requiring emergency surgery. (ORPS Report RP--CHG-TANKFARM-2004-0006)

The metal stanchion had an 18-inch by 18-inch steel plate base with a 42-inch-long pipe welded to the top of it. At each end, the pipe had a steel washer used to thread barrier tape through the stanchions. As the painter picked up the stanchion, the heavy bottom caused him to lose control of it, and the steel washer hit him in the eye. Although the fabrication shop was designated as an eye protection area, the painter had removed his approved, sunglass-type safety glasses when he entered the shop, leaving his eyes unprotected.

The painter had injured this same eye in the past and had limited vision in it. He normally wore sunglass-type safety glasses because the eye was also sensitive to light. When he entered the shop from outdoors he could not see well because of the tinted lenses, so he removed his glasses. He could have picked up another pair of safety glasses in the shop, but apparently did not do so. The painter has not yet regained sight in the injured eye and will undergo additional treatment and surgery.

Occupational-related eye injuries are commonly caused by chemical splashes, metal or plastic debris hitting the eye, tools accidentally striking the face, and improper use of equipment. The Bureau of Labor Statistics (BLS) reports that each day as many as 2,000 workers incur eye injuries related to their jobs. However BLS found that three out of five workers who suffered an eye injury wore no eye protection at all. They also reported that most workers who were hurt while doing their regular jobs without protective eyewear said they did not believe eye protection was required for the task they were performing. Like them, the painter at Hanford most likely assumed that there was no reason for him to wear eye protection to do something as simple as picking up a stanchion, even though he knew eye protection was required when working in the shop.

Safety eyewear should be worn whenever there is any chance that machines or operations present the hazard of flying objects, chemicals, harmful radiation, or a combination of these or other hazards. Figure 2-1 provides a graphic example of why wearing safety glasses is imperative. An installer was applying siding with an air-powered staple gun when a staple hit a metal plate behind the siding and ricocheted back towards his face.

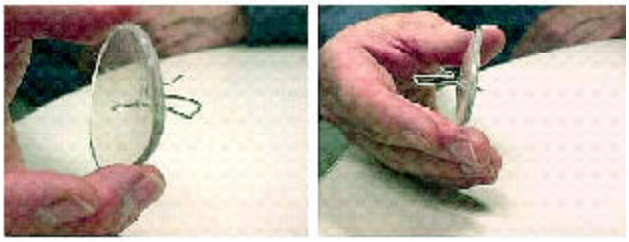


Figure 2-1. Metal staple lodged in safety glasses

As can be seen in the photograph, one leg of the staple penetrated the lens of the installer's safety glasses. The staple hit with such force that the frames of the glasses were cracked. The installer was badly bruised on his eyebrow and cheekbone, but sustained no injury to his eye.

Workers who wear corrective lenses should never assume they do not need to use protective eyewear. The American National Standards Institute (ANSI), which sets standards for safety glasses, requires them to withstand the impact of a quarter-inch steel ball traveling 150 feet per

PREVENTING EYE INJURIES AT WORK

ASSESS — Identify operations and areas that present eye hazards by inspecting work areas, access routes, and equipment and reviewing eye accident and injury reports.

PROTECT — Select protective eyewear designed for a specific operation or hazard. Ensure that eyewear meets current OSHA standards.

FIT — Have eyewear fitted by an eye care professional or by someone trained in fitting safety glasses so that protective eyewear fits properly and comfortably. Require workers to be responsible for their own eyewear.

EDUCATE — Conduct ongoing, mandatory training to maintain and reinforce the need for protective eyewear.

SUPPORT — Set an example. Management support is a key ingredient in successful eye safety programs. Management personnel should wear protective eyewear when and where it is required.

PUT IT IN WRITING— Display a copy of the eye safety policy in areas frequented by workers and include a review of the policy in the orientation process for new workers.

second. Safety glasses and goggles provide protection that prescription glasses, alone, cannot provide when performing tasks that present the potential for an eye injury.

For workers who normally wear corrective lenses, OSHA regulation 1926.102(a)(3) requires use of one of the following types of protective eyewear.

- Spectacles whose protective lenses provide optical correction.
- Goggles that can be worn over corrective spectacles without disturbing the adjustment of the spectacles.
- Goggles that incorporate corrective lenses mounted behind the protective lenses.

OSHA also requires workers who must wear PPE, including protective eyewear, to receive training in its use. Additional information on OSHA requirements can be accessed at www.OSHA.gov. A recent issue of the OE Summary (Issue 2004-01) reported on a researcher at Los Alamos National Laboratory who narrowly escaped serious injury when a solution of hydrochloric/hydrofluoric acid sprayed over the top of his safety glasses and into his eyes. The article includes ANSI Z87.1-1989 recommendations for eye and face protection, including those for wearers of contact lenses and prescription lenses.

These events illustrate that accidents can happen in an instant, and failing to wear personal protective equipment, whether it is eye/face protection or other required PPE, can be the difference between a serious injury and a minor one. Managers should ensure that all workers understand the necessity for wearing the correct eye protection for a task, as well as the importance of wearing eye protection over prescription glasses or incorporating their prescription into safety eyewear. In areas where safety glasses are required, they should be readily available at the entrance to the area.

KEYWORDS: *Personal protective equipment, eye injury, safety glasses, goggles*

ISM CORE FUNCTIONS: *Analyze the Hazard, Develop and Implement Hazard Controls*

3. USE OF INAPPROPRIATE TOOLS LEADS TO INJURIES

On November 11, 2003, at the Brookhaven National Laboratory, an air conditioning mechanic using pliers to remove the seal on a 55-gallon drum of propylene glycol cut his left index finger when the pliers slipped off the metal pull tab (Figure 3-1). The cut severed a tendon, requiring surgical repair. Investigators determined that the pliers were a commonly used but inappropriate tool for this skill-of-the-craft task. (ORPS Report CH-BH-BNL-PE-2003-0017; final report filed January 21, 2004)

Figure 3-1. Metal pull-tab

The mechanic wore cotton, leather-palmed gloves and was using 12-inch water-pump pliers in a rocking motion to open the seal. As he lifted up on the seal, the pliers slipped, and the metal tab cut across the top of the glove into his finger. The reconstructive surgeon stated that the gloves prevented a far more serious injury; nonetheless, the Laboratory purchased cut-resistant gloves and a bung and seal remover that will keep workers' hands out of the way of the seal as it is being removed.

Another event involving the use of an inappropriate tool for a skill-of-the-craft task occurred at Oak Ridge National Laboratory on October 29, 2003. A researcher was holding a band saw similar to the one shown in Figure 3-2 at about a 45-degree angle to cut notches in a stainless steel envelope. Investigators believe that

Figure 3-2. Saw similar to the one that cut the researcher

the blade caught on the envelope and pulled the researcher's hand into the blade. The researcher suffered a significant cut on his hand that required surgery, and he lost 63 days from work. (ORPS Report ORO--ORNL-X10CENTRAL-2003-0009; update/final report issued December 11, 2003)
The steel envelopes are usually notched using a smaller band saw (Wellsaw™) with a finer blade and a table rest designed for use with handheld stock. When the researcher tried to use it to notch the envelopes, the blade slipped off. The researcher decided instead to use the large coarse-toothed saw manufactured by Cosen.

The Cosen saw is designed to be used only in a horizontal position, with the piece clamped in place and safety guards in place. In addition, a rule of thumb for cutting pieces of metal is the "three-tooth" rule; that is, the piece being cut should be wider than three of the saw blade teeth to prevent the blade from catching and pulling the piece. These and other controls were specified in the operating manual, but the researcher did not follow them.

The laboratory issued a lessons-learned document to other potentially affected organizations and conducted retraining on safety requirements for using power saws. The training emphasized stopping work when encountering unsafe conditions.

The improper use or misuse of hand tools can cause minor to serious hand injuries. When the wrong tool is used, or the right tool is used improperly, hand injuries are likely to happen. Over 200,000 hand and finger injuries are reported annually as a result of job-related accidents.

These events illustrate the importance of using the appropriate tool for the job, even for skill-of-the-craft work that does not have a formal procedure. Substituting equipment and using workarounds without a hazard analysis can present the potential for injury.

KEYWORDS: *Seal, drum, injury, skill of the craft, bandsaw*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls*

4. FIRST-AID PROCEDURES NOT FOLLOWED AFTER ACID BURN

On December 6, 2003, at the Savannah River Site, a technician working in a contamination area received a burn on her left palm when nitric acid leaked from an acid dilution vial onto her glove and burned through it. The technician did not follow laboratory first-aid procedures for flushing the burn or use the safety shower/ eyewash station after her injury. Fortunately she was not badly burned and required only an application of antibacterial ointment to the affected area. (SELLS Identifier 2004-SR-WSRC-0004)

The technician was preparing calibration standards using acid dilution vials (Figure 4-1) when she noticed that acid had leaked onto her gloves. She immediately took the gloves off and rinsed them in the sink. When she saw discoloration on the left glove (Figure 4-2) and felt a burning sensation on her palm, she realized she had been burned. Instead of immediately going to the nearest safety shower/eyewash station, the technician left the contamination area and went to the change room, where she flushed her hand for a short period of time. When she returned to the lab and told her manager

Figure 4-1. Acid vial

about the burn, he sent her back to the change room to continue flushing her hands for a full 15 minutes as required by the laboratory safety procedure.

After completing the second flush, the technician noticed a small red blister forming on her palm. She notified the laboratory Shift Operations Manager and went directly to the site medical facility for treatment. However, contrary to site procedures, no one notified the Radiation Control Office about the injury. More information about this event is available on the Lessons Learned website.

Corrective actions taken included reviewing flushing/washing procedures with all laboratory technicians to ensure they understand that the safety shower/eyewash station should be used after an acid burn, as well as the importance of a full 15-minute flush of the burn. Managers will also discuss the need to notify Radiation Control Office personnel with all laboratory personnel and will update the laboratory safety procedure to include steps detailing the notification process.

Figure 4-2. Damaged glove

Until the investigation is completed, technicians will wear a second pair of gloves when handling open acid containers. In addition, laboratory managers will evaluate whether technicians should use volumetric flasks instead of acid dilution vials when preparing standards in the future.

Chemical burns require urgent, effective first-aid. Acid or alkaline solutions that contact unprotected skin burn rapidly through tissue and must be quickly diluted and flushed with large quantities of water. It is essential to go to the nearest safety/eyewash station to flush the burn, dilute the acid, and wash away any particulates as quickly as possible. Using too little water can activate the chemical and produce devastating results; therefore, it is also crucial to adhere to the 15-minute flush requirement following a chemical burn to either the skin or the eyes.

Eyewash stations must be located near the hazard, have unobstructed access, and be properly maintained so they are ready for use in an emergency. OSHA requirements in 29 CFR 1910.151(c), *Medical Services and First Aid*, state that when the eyes or body of a worker may be exposed to injurious corrosive chemicals, suitable facilities for quick drenching must be provided in the work area for immediate use. There is also a close link between these requirements and those in 29 CFR 1910.1200(g), *Hazard Communication,* which requires employers to evaluate hazards and communicate specific information, including proper work practices and protective measures, to workers.

This event illustrates the importance of ensuring that workers are knowledgeable about first-aid procedures and follow them even if an injury appears to be minor. Workers who use hazardous chemicals should receive training in emergency first-aid, including use of eyewash stations and procedures for flushing chemical burns to the body or eyes.

KEYWORDS: *Acid, laboratory, eyewash station*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls*

Agencies/Organizations	
ACGIH	American Conference of Governmental Industrial Hygienist
ANSI	American National Standards Institute
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
INPO	Institute for Nuclear Power Operations
NIOSH	National Institute for Occupational Safety and Health
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
SELLS	Society for Effective Lessons Learned

Units of Measure	
AC	alternating current
DC	direct current
psi (a)(d)(g)	pounds per square inch (absolute) (differential) (gauge)
RAD	Radiation Absorbed Dose
REM	Roentgen Equivalent Man
v/kv	volt/kilovolt

Job Titles/Positions	
RCT	Radiological Control Technician

Authorization Basis/Documents	
JHA	Job Hazards Analysis
NOV	Notice of Violation
SAR	Safety Analysis Report
TSR	Technical Safety Requirements
USQ	Unreviewed Safety Question

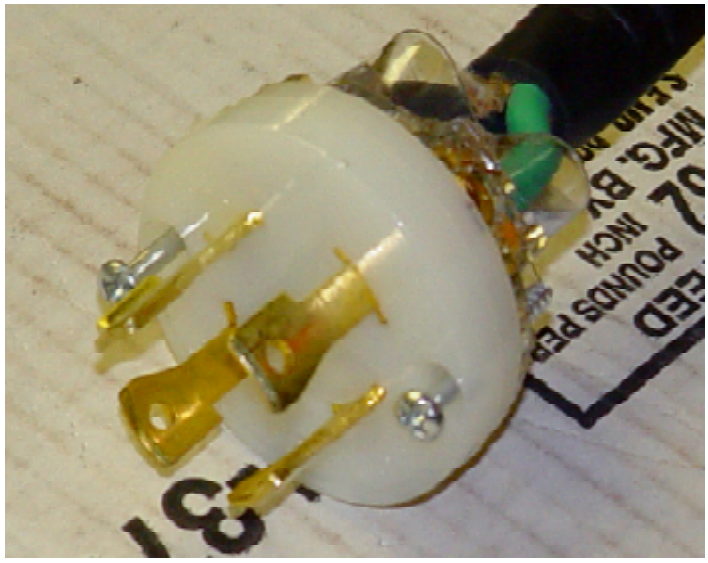
Regulations/Acts	
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
RCRA	Resource Conservation and Recovery Act
D&D	Decontamination and Decommissioning
DD&D	Decontamination, Decommissioning, and Dismantlement

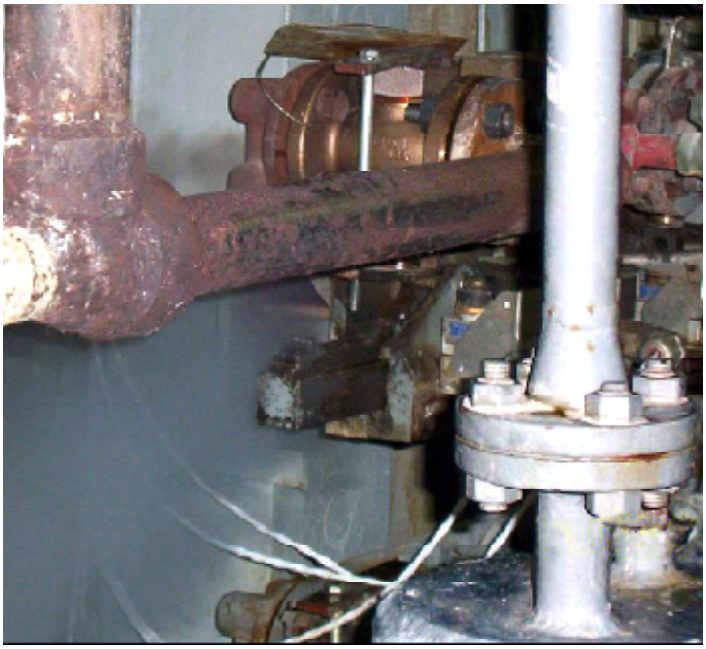
Miscellaneous	
ALARA	As low as reasonable achievable
HVAC	Heating, Ventilation, and Air Conditioning
ISM	Integrated Safety Management
ORPS	Occurrence Reporting and Processing System
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control

OPERATING EXPERIENCE SUMMARY

Inside This Issue

- *Worker cut and bruised after an electrical shock knocks him to the floor 1*
- *Worker narrowly escapes scalding when steam leaks from pipe flange 2*
- *Fall protection lanyard catches worker after the positioning hook comes free 4*
- *Fifty-pound concrete block hits and severely injures worker's foot, resulting in a Type B Accident Investigation 6*





U.S. Department of Energy

Office of Environment, Safety and Health

OE Summary 2004-05

March 8, 2004

The Office of Environment, Safety and Health, Office of Corporate Performance Assessment publishes the Operating Experience Summary to promote safety throughout the Department of Energy complex by encouraging the exchange of lessons-learned information among DOE facilities.

To issue the Summary in a timely manner, EH relies on preliminary information such as daily operations reports, notification reports, and conversations with cognizant facility or DOE field office staff. If you have additional pertinent information or identify inaccurate statements in the Summary, please bring this to the attention of Frank Russo, 301-903-8008, or Internet address Frank.Russo@eh.doe.gov, so we may issue a correction. If you have difficulty accessing the Summary on the Web (URL http://www.eh.doe.gov/paa), please contact the ES&H Information Center, (800) 473-4375, for assistance. We would like to hear from you regarding how we can make our products better and more useful. Please forward any comments to Frank.Russo@eh.doe.gov.

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EVENTS

1. WIRING ERROR RESULTS IN ELECTRICAL SHOCK

On December 3, 2003, at the Hanford Waste Treatment Plant Construction Project, an ironworker repositioning a 480-volt portable electric heater grasped the leg of the heater with one hand while touching a metal table with the other (see Figure 1-1) and received an electrical shock that literally knocked him to the floor. Investigators determined that the power plug for the heater had been miswired. (ORPS Report RP--BNRP-RPPWTP-2003-0006, final report filed January 23, 2004)

The ironworker cut his hand and bruised his knee when he fell backward to the floor. He went to the onsite medical facility for evaluation and treatment. Medical staff found no sign of an electrical burn or entry and exit wounds and treated the injuries he suffered in the fall. An EKG taken the following day was within the normal range.

An experienced journeyman electrician had installed the plug on the new heater a few hours before the incident occurred. He incorrectly connected a hot leg of the three-phase, 480-volt conductor to the ground screw and the ground wire to a power prong. This caused the heater housing to become energized with 277 volts. The electrician did not test for continuity or proper grounding after he installed the plug. Figure 1-2 shows the miswired plug, with the ground (green) wire attached to the power prong.

Figure 1-1. Re-creation of incident

Figure 1-2. The miswired plug

Investigators identified the principal cause of this incident as inattention to detail on the part of the electrician. They also determined that site management had not established a policy requiring testing after performing work on electrical equipment. If the electrician had checked his work, he probably would have caught the error before allowing the heater to be used. The electrician resigned because he held himself accountable for creating the unknown electrical hazard produced by the miswired plug. However, at the time of the incident, it was not standard practice for electricians to conduct acceptance testing after wiring components.

Investigators learned that no one controlled and tagged the heater with a "Do Not Operate" placard immediately after the occurrence. They also determined that proper notifications were not made until the day after the incident.

Corrective actions included the following.

- Develop a guidance document instructing electricians to inspect their work and perform circuit testing at the completion of a task.
- Develop a grounding program, with procedures, including those for circuit and continuity testing.
- Issue instructions to site workers to tag equipment "Do Not Operate" immediately when they suspect it to be hazardous or defective.
- Reiterate the need for prompt notification and categorization of reportable occurrences.

GOOD PRACTICES FOR ELECTRICAL COMPONENT MODIFICATIONS

- Perform a self-check of work before putting the component or equipment into service.
- Require competent, independent, verification of tasks as they are completed.
- Perform checks on modified circuitry (e.g., voltage, continuity, phasing and polarity).
- Avoid distractions when performing tasks that could create hazards if not performed correctly.
- Perform integrated acceptance testing of the component or equipment upon the completion of work.

Wiring errors have caused several other electrical shock events reported in ORPS. In fact, two such events occurred on May 27, 2003. On that day at the Los Alamos National Laboratory, a machinist received an electrical shock when he simultaneously touched a mobile welding cart and another piece of equipment. The shock was of such a magnitude that it caused numbness in the machinist's left arm that lasted for several days. Improper wiring of the 480-volt welding cart plug (i.e., reversal of power lead and the ground lead) resulted in a measured 260 volts on the body of the welding cart. (ORPS Report ALO-LA-LANL-NUCSAFGRDS-2003-0002)

On May 27, 2003, at the Oak Ridge Spallation Neutron Source construction site, a worker received an electrical shock when he touched a metal component while working on a locked-out circuit. Investigators discovered a miswired 120-volt receptacle inside a communication cabinet that had a hot lead connected to the ground terminal and the ground lead connected to a power terminal. The worker experienced no lasting effects from the electrical shock. (ORPS Report ORO--ORNL-X10SNS-2003-0002)

All cord sets and receptacles that are not part of the permanent wiring of a building or structure, as well as equipment connected by cord or plug, should be tested in accordance with an assured grounding program. Program requirements are stated in National Electrical Code®, Section 305 and in 29 CFR 1926.404, *Wiring Design and Protection*, section (b)(1)(iii). In addition, the Occupational Safety and Health Administration (OSHA) requires two tests. The first is a continuity test to ensure that the equipment grounding conductor is electrically continuous. It must be performed on all cord sets and receptacles and on cord- and plug-connected equipment that is required to be grounded. The second test is to ensure that the equipment grounding conductor is connected to the proper terminal. These tests are required before first use, following repairs or suspected damage, and at 3-month intervals.

These events demonstrate that electrical wiring errors resulting from inattention to the task at hand can create life-threatening hazards for workers. After performing modifications or maintenance on electrical components, it is important to re-check the work, have an independent verification performed, and conduct acceptance testing. If these checks are not performed or are performed incorrectly, component wiring errors can result in unsafe conditions that can cause severe injuries to unsuspecting workers.

KEYWORDS: *Electrical shock, electrical safety, inattention to detail, miswired equipment, post-work testing*

ISM CORE FUNCTION: *Perform Work within Controls*

2. NEAR MISS TO SCALDING WHEN STEAM LEAKS FROM PIPE FLANGE

On November 20, 2003, at the Savannah River H-Canyon facility, a construction worker preparing to remove insulation from a steam manifold assembly narrowly escaped being scalded when 365° F steam leaked from a defective pipe flange. The worker was removing the piping insulation in proximity to a gang valve

that provided steam for process transfers. Workers were aware that the flange sometimes leaked, and had closed the steam stop valve, but they did not lock or tag it out. No injuries resulted from this near-miss occurrence. (ORPS Report SR--WSRC-HCAN-2003-0030, final report filed January 2, 2004)

Facility policy for removing insulation from steam pipes did not require the energy source to be locked closed and posted, with the steam stop valve barricaded, because the system would not be penetrated. However, a lockout/tagout should have been applied because workers knew that the flange leaked at the work location and that pressurized steam in the line could present a scalding hazard. Work planners also knew the task involved erecting a plastic tent (glovebag) to contain airborne asbestos and that heat from the steam lines could compromise the integrity of the glovebag. Investigators identified these work planning deficiencies as the root cause of the occurrence.

Although they used a "plan-of-the-day" process, work planners did not recognize the conflicts between the insulation removal task and the process transfer task. They performed a hazards analysis as part of the work planning, but incorrectly concluded there were no harmful sources of energy in the work area. Figure 2-1, a photograph taken after the insulation was removed from the piping, shows steam leaking from the defective flange.

Investigators found evidence of several inadequacies in work planning and communications. First, the shift operations manager should have recognized the proximity of the work location to the equipment providing steam flow for the process transfer. In addition, control room personnel should have provided communication between the workers removing insulation and operations personnel to ensure that the hazardous energy source (steam line) remained isolated. Investigators identified this lack of coordination between the insulation removal task and the process transfer task as a second causal agent for the occurrence.

Corrective actions resulting from this incident included the following.

- Facility management will issue a standing order to establish a lockout/tagout on the steam stop valve for any insulation work in the area of known steam leaks.
- Facility management will issue an operating experience description to the planning group to ensure that all sources of hazardous energy are identified in task hazards analyses.
- Facility personnel will walk down work spaces to identify unsafe conditions and ensure that appropriate postings and/or barricades are established.

Work planning inadequacies contributed to many occurrences reported in ORPS. On September 10, 2003, at Rocky Flats, workers isolated and drained a riser for the building automatic sprinkler system and began to remove a sprinkler head. Water started to flow from the loosened sprinkler head and a riser firewater flow alarm was received. Workers had isolated the wrong

Figure 2-1. Actual steam leak

riser because of inadequate work planning, inadequate verification of orally transmitted information on equipment status, and failure to walk down the piping to ensure that the proper sections of the system were isolated. (ORPS Report RFO--KHLL-WSTMGTOPS-2003-0017)

Attachment I to DOE Order 5480.19, *Conduct of Operations Requirements for DOE Nuclear Facilities,* chapter 1, section C.6, "Planning for Safety," states:

> Facility guidance should exist which describes safety preplanning requirements for all operational activities. The guidance should explain the role of safety analysis reviews, job safety analyses, and the handling of safety matters. All operations personnel should understand the safety planning requirements.

These events illustrate the importance of careful work planning in the interest of ensuring safety in the workplace. Work planning includes performing a comprehensive hazards analysis, implementing hazard controls, and developing formal procedures for performing work within established controls. Incomplete hazards analyses, inadequate hazards controls, and improvised procedures jeopardize the safety of workers.

GOOD WORK PLANNING PRACTICES

- Perform a comprehensive hazards analysis that identifies all the hazards associated with the work scope
- Document the results of the hazards analysis in a form suitable for input to the work planning process.
- Identify hazard controls to be applied during the performance of the work.
- Document the needed hazard controls in a format suitable for incorporation into work plans and procedures.
- Establish formal procedures to the degree required to ensure compliance with the hazard controls.
- Walk down the work to be performed in the workplace with the workers and supervisors involved.
- Before beginning work, present a briefing that describes the hazards involved, the controls established, the need to follow procedures, and the need to stop work if unanticipated conditions arise.

KEYWORDS: *Near miss, steam scalding hazard, steam leak, lockout/tagout, job planning, communications*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls*

3. FALL PROTECTION NEAR MISS

On March 22, 2004, at the Hanford Waste Treatment Plant construction project, an ironworker fell nearly 6 feet before his fall protection equipment arrested the fall when he was about 3 feet above a concrete basement slab. The worker's fall protection system, which included a body harness and lanyard, saved him from a serious injury. (ORPS Report RP--BNRP-RPPWTP-2004-0004)

The iron worker was securing splice bars on a wall of reinforcing rods (rebar) about 14 feet above the slab. He was using a rebar chain assembly (Figure 3-1) attached to the front of his harness to position himself on the rebar wall so he could work with both hands. However when he changed positions during the task, he apparently did not ensure that the positioning hook was fully engaged. When he leaned back, the positioning hook came free and he fell.

Figure 3-1. Chain assembly and positioning device

The worker was using a double shock absorber/ lanyard system (Figure 3-2). This system allows the worker to be tied off with one lanyard while he is moving the other one. When the worker began to

Figure 3-2. Double-lanyard

fall, the lanyard performed according to design and stopped his fall before he hit the concrete floor.

The lanyard the ironworker was using attaches to a full-body harness (Figure 3-3), and is designed to decelerate a fall, bringing the worker to a smooth, easy stop. Shock-absorbing material in the lanyard's inner core is surrounded by an extra-strong outer jacket. When a force of about 600 pounds is exerted on the lanyard, the outer jacket extends to its full length and acts as a backup web lanyard. After the worker's fall was arrested, he regained his footing and re-ascended the rebar wall, apparently preparing to return to work. A supervisor saw the lanyard warning flag (indicating that it had been used during a fall) and told the worker to come down from the wall to replace the lanyard. The worker was treated for an abrasion at the project medical facility and returned to work with a new fall protection system, full body harness, and shock-absorbing lanyard.

Several actions were taken as a result of this occurrence.

- The worker involved in the fall discussed the incident and lessons learned with co-workers before work began the next morning.
- Supervisors reminded the workers that all positioning and fall protection devices need to be verified as operable before relying on them.
- Supervisors reminded the workers that fall protection equipment involved in a fall needs to be removed from service immediately (this is important because the device is only designed for one fall).

OSHA requirements for fall protection are presented in 29 CFR 1926, Subpart M, Standard 1926.502, *Fall Protection Systems Criteria and Practices.* Section (d) of this standard is titled *Personal Fall Arrest Systems,* and section (e) is titled *Positioning Device Systems.* Each section presents requirements for several fall protection-related topics, including anchorages, support lines (e.g., lanyards and lifelines), connectors (e.g., D-rings and snaphooks), body belts and harnesses, and equipment inspection.

Figure 3-3. Typical full-body harness

A search of the ORPS database for other events where fall protection lanyards worked properly revealed several occurrences. On June 5, 2003, at the Miamisburg Closure Project, a construction worker tripped on a protruding bolt while disassembling a 16-foot-high steel-frame scaffold and fell through an opening in the top of the scaffold. The worker's fall was arrested by a properly installed lanyard and he was not seriously injured. However, he struck the scaffolding and sustained arm and back abrasions. (ORPS Report OH-MB-BWO-BWO04-2003-0008)

On August 3, 2000, at the Savannah River Site, workers were removing sections of deck grating on an elevated platform to access a pump at a cooling tower. A worker wearing a fall protection harness attached to a lanyard lost his balance and fell through an opening where grating had been removed. The lanyard arrested the worker's fall and suspended him approximately 7 feet above the ground. A loose piece of grating subsequently fell through the opening and struck the suspended worker, causing an open wound on his left leg. (ORPS Report SR--WSRC-FDP-2000-0001)

These events underscore the importance of using safe practices when working at elevation, including the proper use of positioning and fall protection equipment. Workers need to stay focused on the task at hand and pay attention to their surroundings to avoid falls. These occurrences also illustrate that sometimes the benefit from fall protection is not injury

avoidance, but rather changing a potential serious injury to a minor injury. Workers and supervisors should not lose sight of the fact that fall protection equipment, when properly selected and used, does work in protecting the lives of workers.

KEYWORDS: *Fall protection, body harness, lanyard, positioning device, D-ring, anchorages*

ISM CORE FUNCTIONS: *Perform Work within Controls, Provide Feedback and Continuous Improvement*

4. PIPEFITTER'S FOOT INJURY RESULTS IN TYPE B ACCIDENT INVESTIGATION

On December 17, 2003, at the K-31 building, East Tennessee Technology Park, a pipefitter using a wrecking/pry bar to remove concrete blocks from the inside web of a steel column severely injured his left foot when a block weighing nearly 50 pounds fell about 11 feet and struck his steel-toed boot. The pipefitter, who refused medical attention at the time of the injury, later required surgery to relieve the pressure in his swollen foot. Surgeons also inserted pins in two of his toes, and a few weeks later amputated his fifth toe and performed skin grafts because of complications from the injury. The Oak Ridge Operations Office Manager convened a Type B accident investigation when he learned of the severity of the pipefitter's injuries. (ORPS Report ORO--BNFL-K31-2003-0003)

Demolition of the K-31 control room began in December 2003. Workers used a trackhoe with a bucket attachment to knock down some block walls and then pried concrete blocks loose by hand when access became difficult.

The pipefitter had been removing blocks with the wrecking/pry bar and a sledgehammer for 2 days before the accident without incident. At the time of the accident, he was unable to pry loose blocks located at chest height in the column (Figure 4-1). He stopped working and, as he began to walk away, the top block fell, glanced off his raised face shield, and struck his left foot. After the accident, the blocks between the top block and those at chest height fell out of the column. Reportedly, no one in the area observed this.

Figure 4-1. Wide-flange column involved in the accident (blocks removed)

Five minutes later, the Area Manager noticed the pipefitter limping and asked what happened. The pipefitter replied that a block had struck him on the steel toe of his boot. The Area Manager asked the pipefitter if he needed to go to the site medical clinic, but the pipefitter declined treatment and said he would be all right if he walked it off.

The pipefitter showed the Area Manager the method he had used to remove the blocks, all of which were no higher than 5½ feet above the floor during the demonstration, and a couple of the remaining blocks fell out of the column. The Area Manager did not recognize the event as a near miss after the demonstration, and did not stop work on block removal with hand tools.

The Area Manager told the pipefitter that if his foot continued to hurt he should go to the site medical clinic. Other workers in the area, including the foreman, noticed the pipefitter limping, and repeatedly suggested that he go to the clinic, but the pipefitter stated that he did not think he was hurt that badly. He remained at the job site, taking intermittent rest breaks, until early afternoon and then drove home. When he got home, he removed his work boot and saw blood in it, so he applied ice to his foot. When the bleeding became worse, the pipefitter contacted his wife, who took him to the hospital emergency room.

The pipefitter was admitted with a diagnosis of compartment syndrome (pressure and swelling) in his left foot and dislocated fourth and fifth toes. He underwent surgery on the bottom

of his foot to relieve pressure, and surgeons also inserted pins in the dislocated toes. After the holidays, the pipefitter returned to the hospital, where surgeons amputated his fifth toe, removed dead tissue, and performed a full-thickness skin graft. He remained in the hospital for 8 days. His physician released him to return to work on restricted duty on February 3, 2004.

The day after the accident, the pipefitter's wife reported his injury to the Area Manager, who informed BNFL management that afternoon. BNFL intended to stop work on concrete block demolition and schedule a critique when they learned about the pipefitter's hospitalization; however, the stop-work decision was not documented and apparently was never communicated to the general foreman. The general foreman went to the accident site and saw that the remaining concrete blocks had been removed from the column by other members of the work crew. He discussed the situation with the foreman and crew and decided that any further block removal would be done from the top of the column down, using a scissor lift, thus ensuring that the workers would not be struck by falling blocks.

On December 19, the Building Manager discontinued the critique process, and the Deputy General Manager elevated the investigation to Type C. On January 13, 2004, the Deputy General Manager signed a formal Stop Work, and DOE ordered a Type B investigation of the accident because of the pipefitter's second hospital stay.

The Type B accident investigation report was completed and approved on February 24, 2004. The investigation team identified 12 Judgments of Need, including the need to (1) improve communication between managers and workers, (2) improve worker involvement in the planning process, (3) ensure that managers and workers comply with work controls, (4) use stop-work authority when unexpected or unsafe conditions exist, and (5) verify that corrective actions are taken to prevent recurrence.

The team stated that although BNFL policy requires injured workers to report to the site medical clinic for evaluation, the pipefitter failed to do so, and his manager suggested, but did not require, that he do so. They also stated that both the foreman and the work crew recognized that the difficulty in reaching the columns with the trackhoe to remove blocks presented a change in working conditions, but no one thought to stop work and evaluate the changed condition until several weeks had passed.

The team believed that because the job was nearing completion, managers and workers were more focused on finishing the job than working cautiously. The following text box gives some recommendations for working with an emphasis on safety.

FOCUS ON SAFETY

- All workers and managers involved in a task should contribute to the work planning process.
- Mentally walk down the job before starting, noting any changed conditions.
- Stop work and reevaluate safety when conditions change.
- Communicate concerns to management.
- Question anything that doesn't seem right.
- Don't hesitate to invoke stop-work authority.
- Consider using the buddy system if possible.
- Look out for co-workers as well as for yourself.
- Foster a culture of emphasizing safety over task completion.

This event illustrates the necessity of seeking immediate medical attention for injuries at work and stopping work when conditions change. Workers should think in terms of working safely instead of finishing a task quickly.

KEYWORDS: *Injury, Type B, work planning, stop work*

ISM CORE FUNCTIONS: *Analyze the Hazard, Develop and Implement Hazard Controls, Perform Work within Controls*

Agencies/Organizations	
ACGIH	American Conference of Governmental Industrial Hygienist
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SELLS	Society for Effective Lessons Learned

Units of Measure	
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v/kv	volt/kilovolt

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ISM	Integrated Safety Management
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QA/QC	Quality Assurance/Quality Control

Think Outside the 'Junction Box'

Developing Innovative Approaches to Electrical Issues

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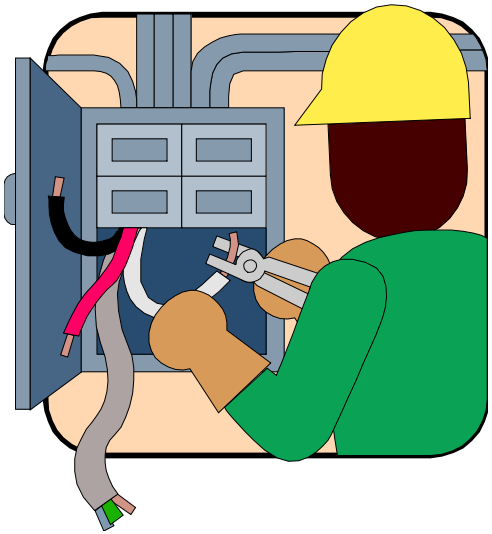


DOE Electrical Safety Committee Meeting; Las Vegas, NV

Tuesday, July 27th 9:15 a.m. -- 10:00 a.m.

Prepared under contract number DE-AC04-01AL66850 for the United States Department of Energy

Problem / Solution

The Four "I's"

Issues, Inspiration, Innovation, Incorporation

Every person, program, company, and site:

1. ***has "issues" within***
2. ***has "innovative" ideas and approaches***
3. ***has the capacity to "inspire" themselves and others to accomplish great things***
4. ***can find ideas to "incorporate" and improve their processes***

Critical Questions

Ask Yourself

1. *What **issues** do I have in my electrical program?*
2. *What **innovative** ideas and approaches do we currently use at my site?*
3. *What ideas can **I share** to **inspire** others?*
4. *What ideas can I borrow to **incorporate** into my processes to make them better?*

INSPIRATION

Analogy

Messenger	/	*Farmer*
Idea or Thought	/	*Seed Planted*
Consideration	/	*Fertilizes*
Develop	/	*Grows*
Launch Initiative	/	*Harvest*

Sometimes it's a <u>good</u> crop -- Sometimes it's <u>NOT</u>

INSPIRATION

2001

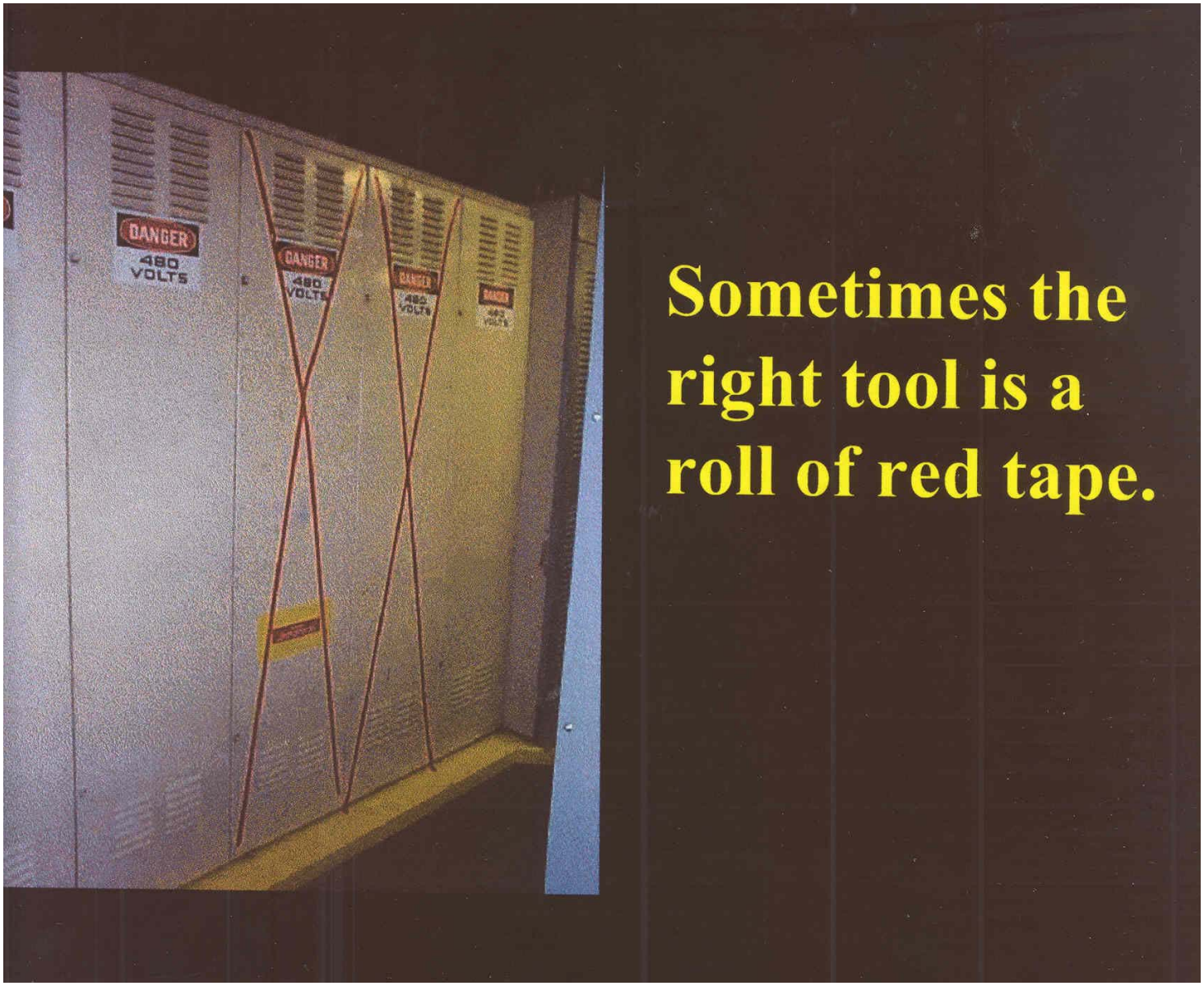
Farm -- Princeton Plasma Physics Lab (PPPL)

Season -- DOE Electrical Safety Workshop

Farmer -- Landis Floyd, DuPont

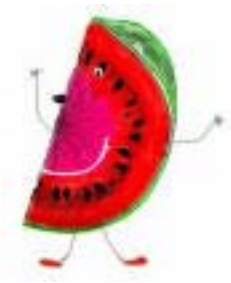
Seed -- Safety Examples for LOTO

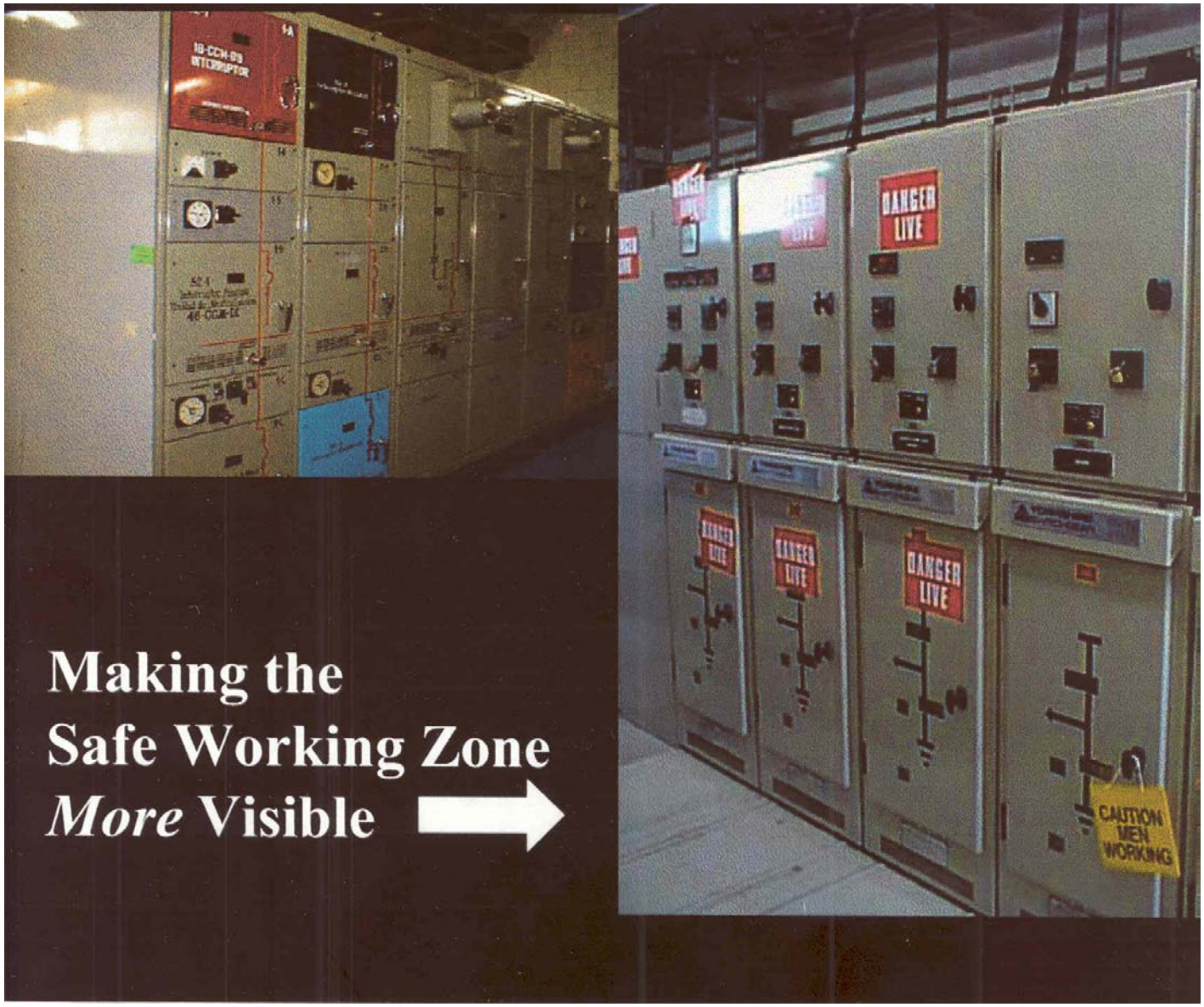
Got ME Thinking !! **(ideas)**



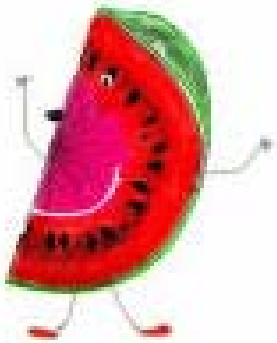
Sometimes the right tool is a roll of red tape.

IDEA

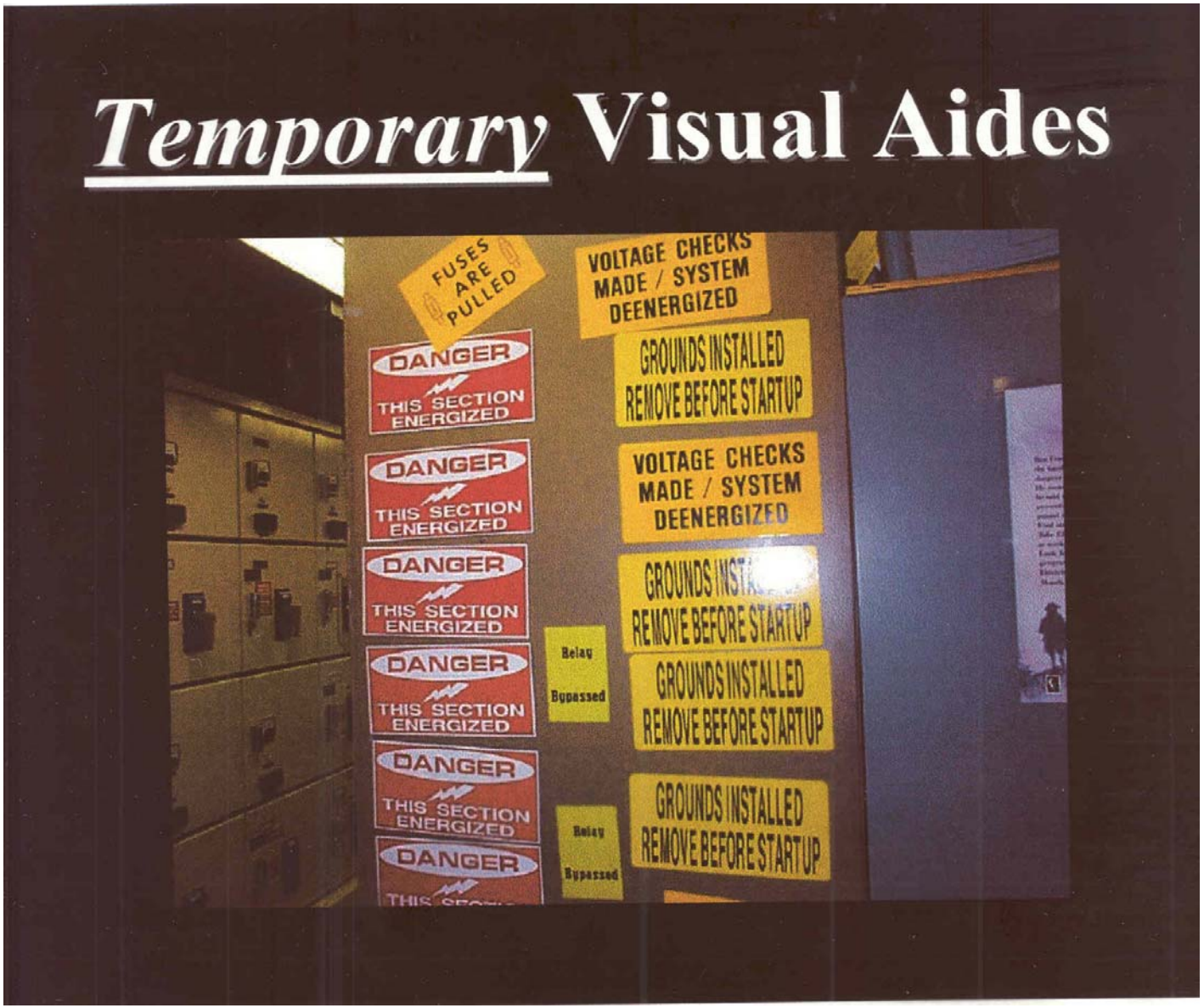



DANGER
LIVE
CAUTION
MEN
WORKING
Making the
Safe Working Zone
More Visible

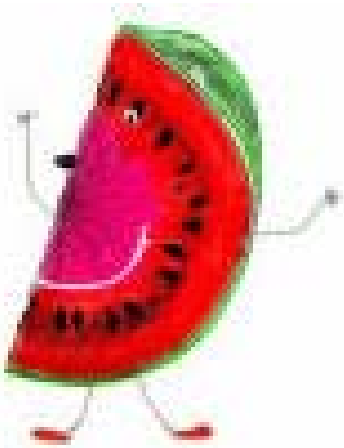
IDEA !



Temporary Visual Aides



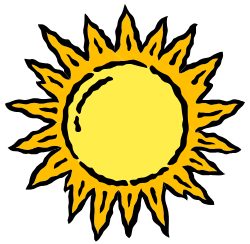
IDEA !!



Learn From Others
Share With Others

Adjustable Carts

Ergo in the Substation



Learn From Others
Share With Others

Cooling Vests

Improved Worker Comfort

COOLING VEST

For use with ARC flash suits.

Learn From Others
Share With Others

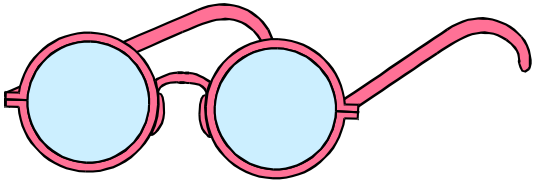
Contact Cards

Data Readily Available

Learn From Others
Share With Others

Safety Glasses

Work is Overhead



Learn From Others
Share With Others

Internal Components Hidden

External Indication

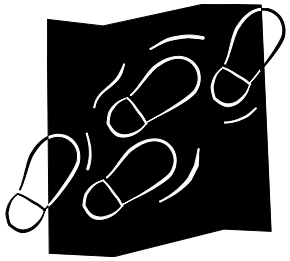
Learn From Others
Share With Others

Electrical Gloves

(In Progress)

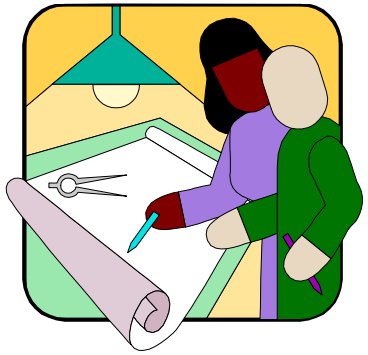
Expiration Dates

Your Turn
Open Forum

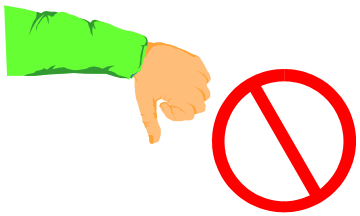


What are ideas that you have had or used ?

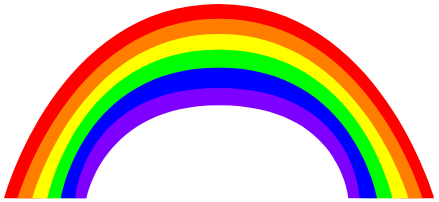
What are ideas that you have seen from others ?



What ideas are you willing to share ?

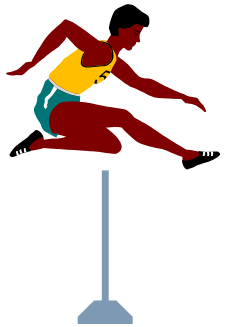


INNOVATION



Summary

Open Forum



We can <u>ALWAYS</u> improve our processes

Inspiration can come from <u>MANY</u> sources

Innovation can come in <u>MANY</u> forms

Use this week to continue to consider your issues, discuss various ideas, and look for ways to improve.

1. ***<u>Take</u> 1 thing home and TRY it***
2. ***<u>Give</u> 1 idea away to someone else***

QUESTIONS / COMMENTS

- Who ?
- What ??
- Where ???
- When ????
- Why ?????
- How ??????

Thanks for the Opportunity to Share

Survey of Local Codes and Standards

Chuck Monasmith
Fluor Government Group
Richland, Washington

Why Did I Ask About Local Codes and Standards?

DOE Sites have: Industrial Production Facilities, Scientific Laboratory Facilities, and Power Transmission Facilities.

DOE Site neighbors have: Industrial Production Facilities, Scientific Laboratory Facilities, and Power Transmission Facilities.

Why Did I Ask About Local Codes and Standards?

DOE Sites have: Industrial Production Facilities, Scientific Laboratory Facilities, and Power Transmission Facilities.

DOE Site neighbors have: Industrial Production Facilities, Scientific Laboratory Facilities, and Power Transmission Facilities.

Why Do We Not Have The Same Safety Requirements?

Let’s Have A Survey!

What Do I Want to Survey?

1. Electrical Worker Credentials
2. NEC Inspections
3. Local Codes and Standards
4. Authority for Using Local Codes
5. Listing and Labeling

Survey Responders

Ames Laboratory

Brookhaven National Labs

Fermi Labs

Hanford

Lawrence Livermore National Labs

Princeton Plasma Physics

Sandia National Labs

Thomas Jefferson National Accelerator

Worker Credentials

Maintenance Electricians –

No License Required

Construction Electricians – 50% of DOE Sites Require License. 50% of Non-DOE Site Require License

Electrical Contractors - are licensed both on and off DOE Sites.

NEC Inspections

Are new or modified installations inspected?

- Only 55% said yes!

Credentials of NEC Inspector?

- Majority require IAEI/ICBO Certification

Who does the NEC Inspector work for?

- Safety or QA Independent from the Designer and Installer.

Codes and Standards

Do Local Codes Supplement NEC or 70E?

Half YES Half NO with one N/A

Do Local Codes Apply on Your Site?

Majority YES

Authority

By What Authority Do You Enforce Local Codes?

The Majority said DOE Order 440.1A, Others Said Site Safety Manuals.

DOE Order 440.1A

Worker Protection Management for DOE Federal and Contractor Employees

4. REQUIREMENTS. DOE Elements shall:

a. Implement a written…

b. Establish written policy, goals,…

l. Comply with the following worker protection requirements:

(5) NFPA 70

m. Additional requirements for specific functional area are contained in Attachment 1, Functional Area Requirements for DOE Elements.

Attachment 1
FUNCTIONAL AREA REQUIREMENTS FOR DOE ELEMENTS

1. CONSTRUCTION SAFETY
2. FIRE PROTECTION
3. FIREARMS SAFETY
4. EXPLOSIVES SAFETY
5. INDUSTRIAL HYGIENE
6. PRESSURE SAFETY

   (3) the strictest applicable State and local codes

7. MOTOR VEHICLE SAFETY
8. SUSPECT AND COUNTEFEIT (S/CI) ITEM CONTROLS

Attachment 2

CONTRACTOR REQUIREMENTS DOCUMENT

WORKER PROTECTION MANAGEMENT FOR DOE CONTRACTOR EMPLOYEES

12 k. NFPA 70 National Electrical Code

14. Construction Safety

15. Fire Protection

16. Firearms Safety

17. Explosives Safety

18.Industrial Hygiene

19. Occupational Medicine

20.Pressure Safety

(3) the strictest applicable State and local codes

21. Motor Vehicle Safety

22. Suspect and Counterfeit Item (S/CI) Controls

Conclusion

According to DOE 440.1A, we cannot use anything more than the NEC and NFPA 70E for electrical safety requirements.

Site ES&H Manuals

Let me tell you a Story…

There is a “Must-Do” List in your contract

- There is <u>not</u> a “Must-Not-Do” List in your contract

The Must-Not-Do List is EVERYTHING not on the Must-Do-List

It’s Good News

The Elephants Are All Running in the Same Direction!

There’s a Few Keeping Pace With the Group…. They’re on the Edges of the Herd

We Need a Bigger Prodding Stick to Get The Herd Running Together

Summarizing Thoughts

DOE Contractors Want to be as Safe as Their Neighbors.

DOE Would Like its Contractors to be as Safe as Their Neighbors.

DOE Must Give Specific Direction to Use the Toughest Electrical Safety Codes We Can Find.

Ground Clamp Loose from Rusted Bolt

Flexible Cords Secured to Tree

Rusted Fixture and Lost Equipment Grounding at Walkway Lighting

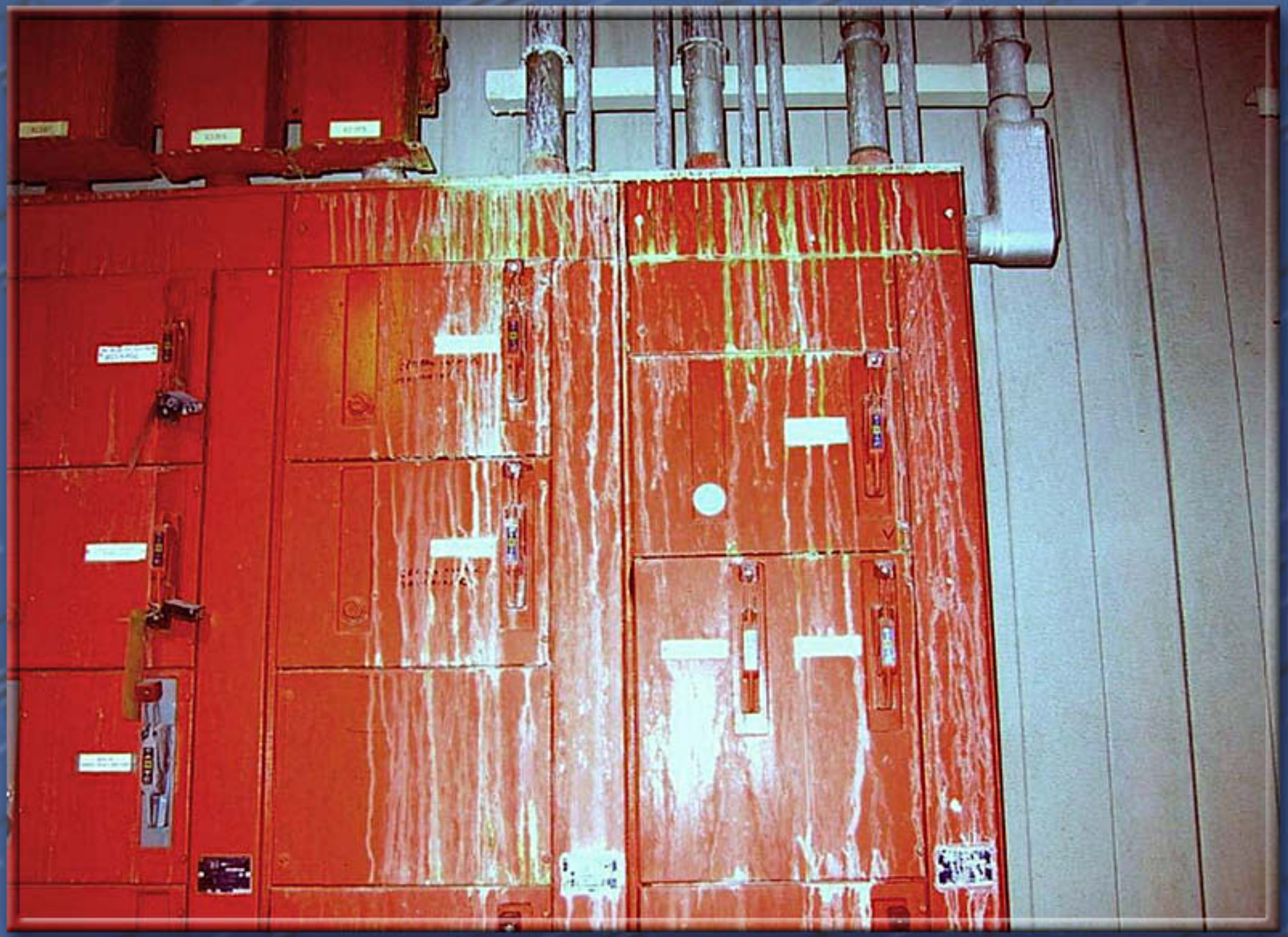
Service Entrance Conductor Drip Loop To Low

Conduit Rusted Away Under Parking Structure Expansion Joint

Pull Box in Driveway Damaged by Truck

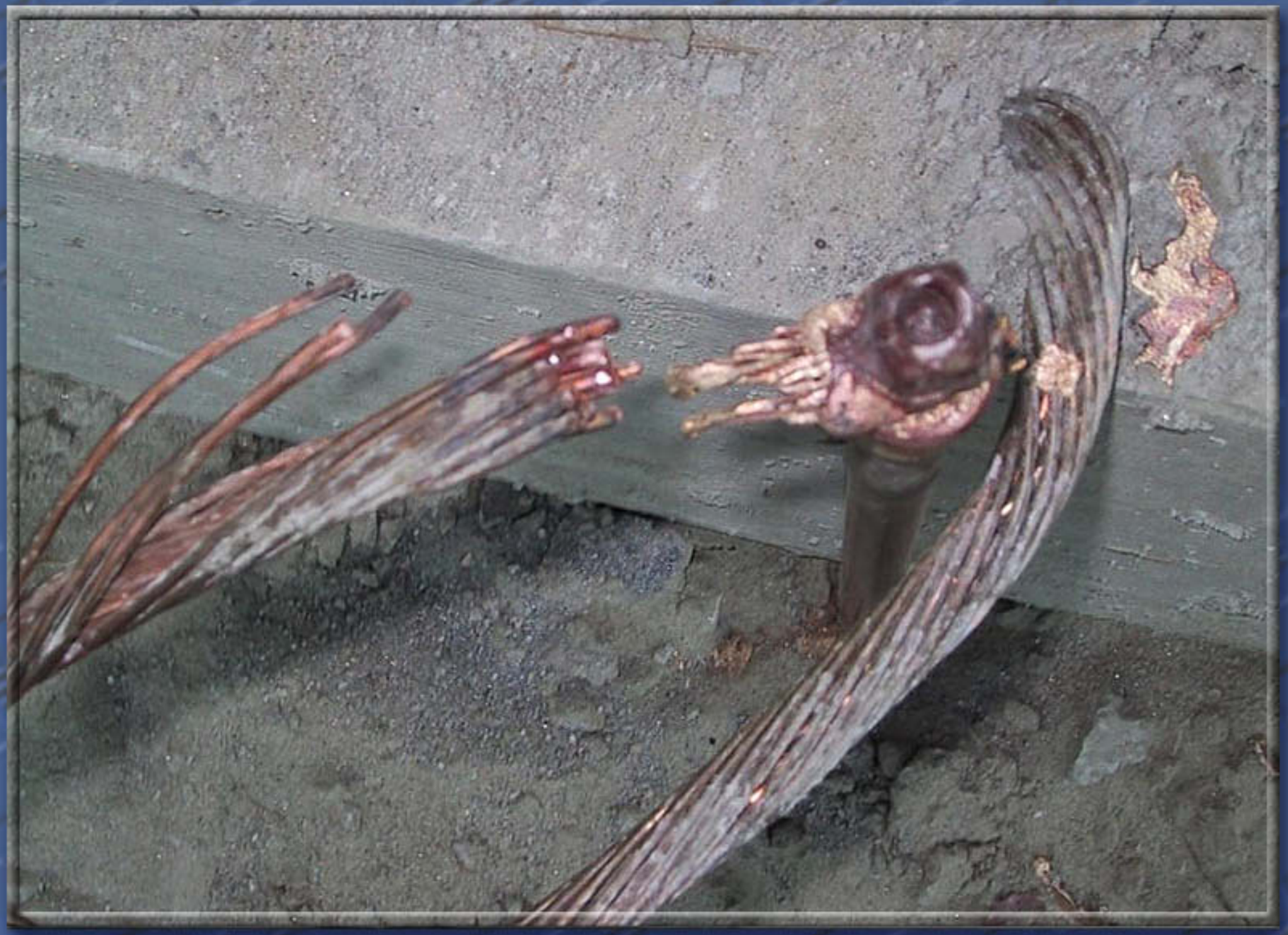
Broken Cover on Outdoor Receptacle

Damaged Nonmetallic Raceway in Planter



Leaking Water Pipes Above Electrical Equipment

Foreign Systems Installed Over Electrical Equipment



Improper Exothermic Weld to Ground Rod

Rusty Connection at Termination of Grounding Electrode Conductor

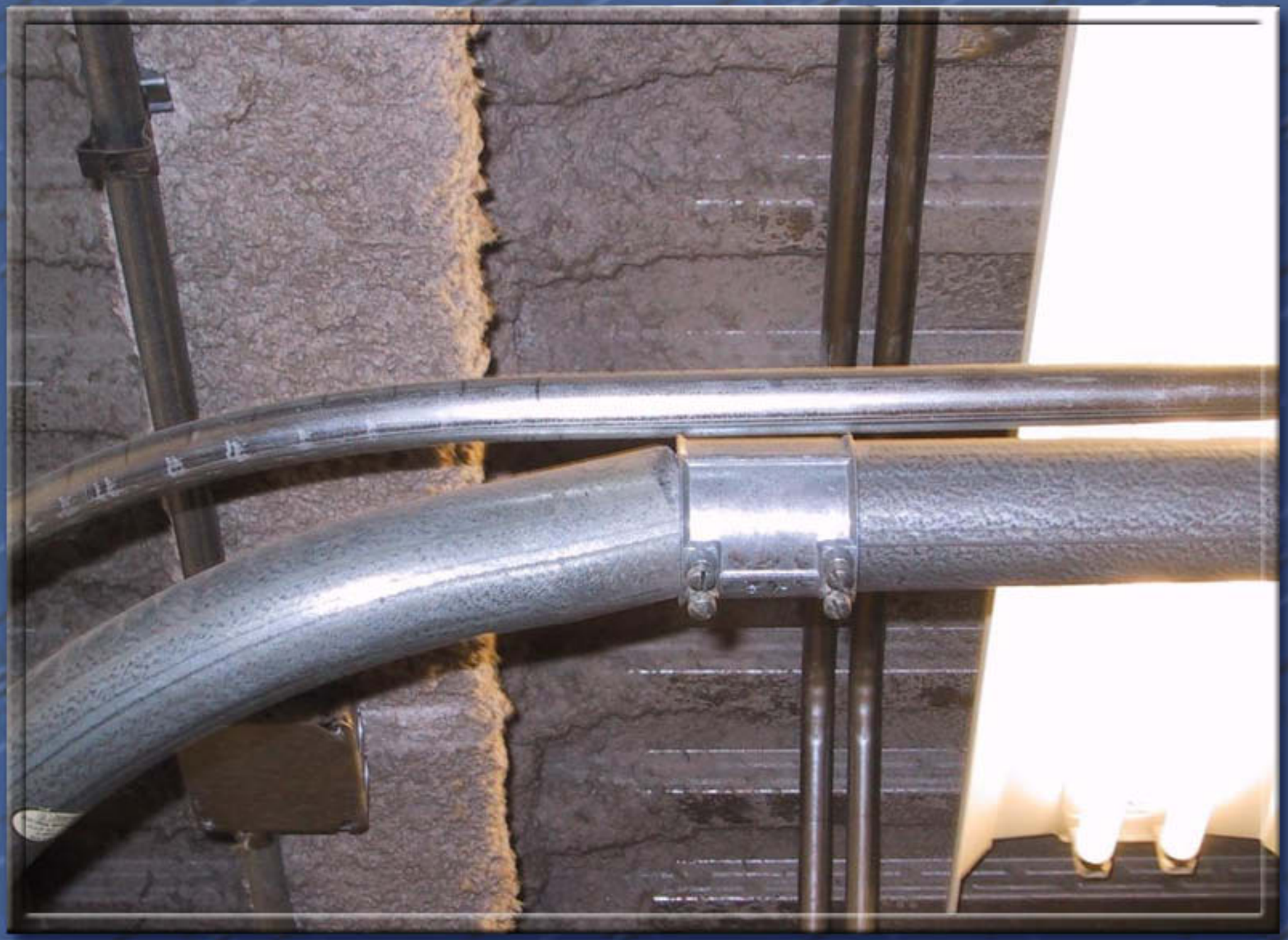
Open Wire Not Permitted for Temporary Lighting on Construction Site

Box Not Suitable for Use in Damp or Wet Location

Plumbing Pipe Improperly Used for Electrical System

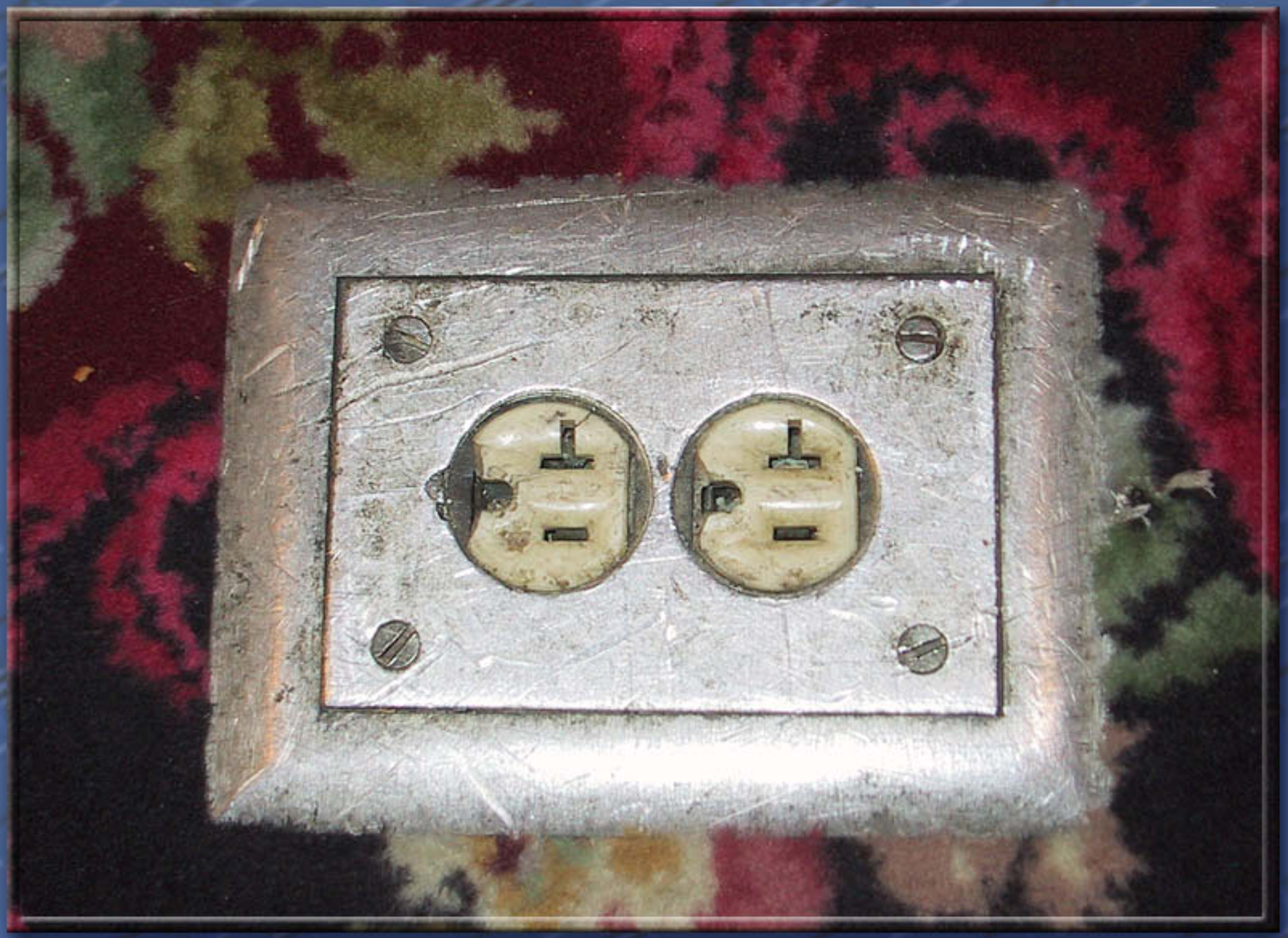
Protection Against Abrasion Improperly Installed

Broken Receptacle and Exposed Line Terminals at Outlet



Connection at Fitting Loose in EMT Feeder

Tape Used to Cover Damaged Nonmetallic Conduit



Missing Covers and Broken Receptacle in Hotel

Improper Termination of Supply to Outside Lighting in Riverwalk

Cover Improperly Secured with Tape

Exposed Live Conductors at Base of Tree

Lack of Proper Working Space in Front of Air Conditioning Disconnects

Use of Overhead Extension Cords for Permanent Supply to Equipment

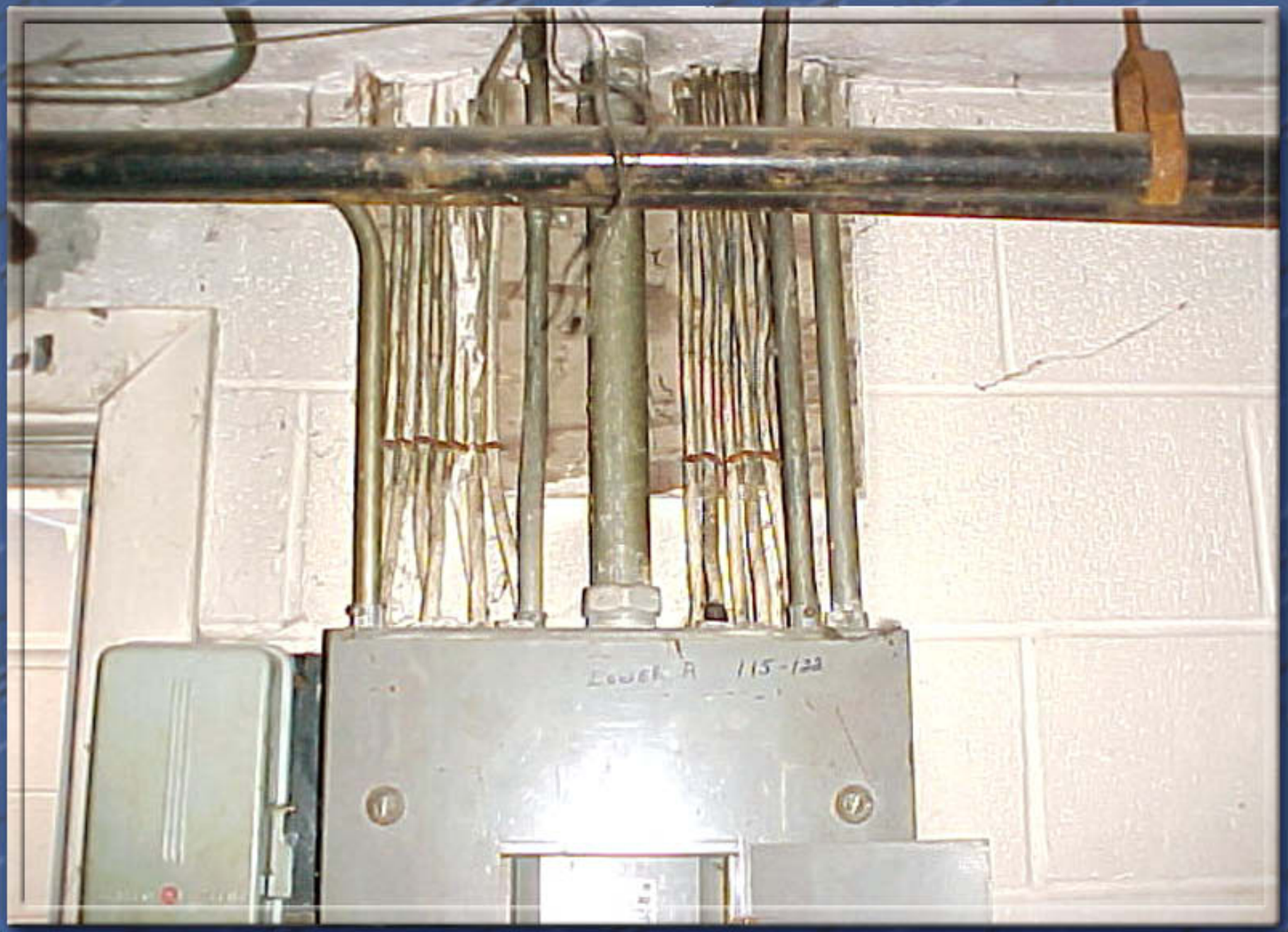
Damaged Service Laterals from Installation of Communication Circuits

Loose Connection in EMT to Light in Front of Restaurant

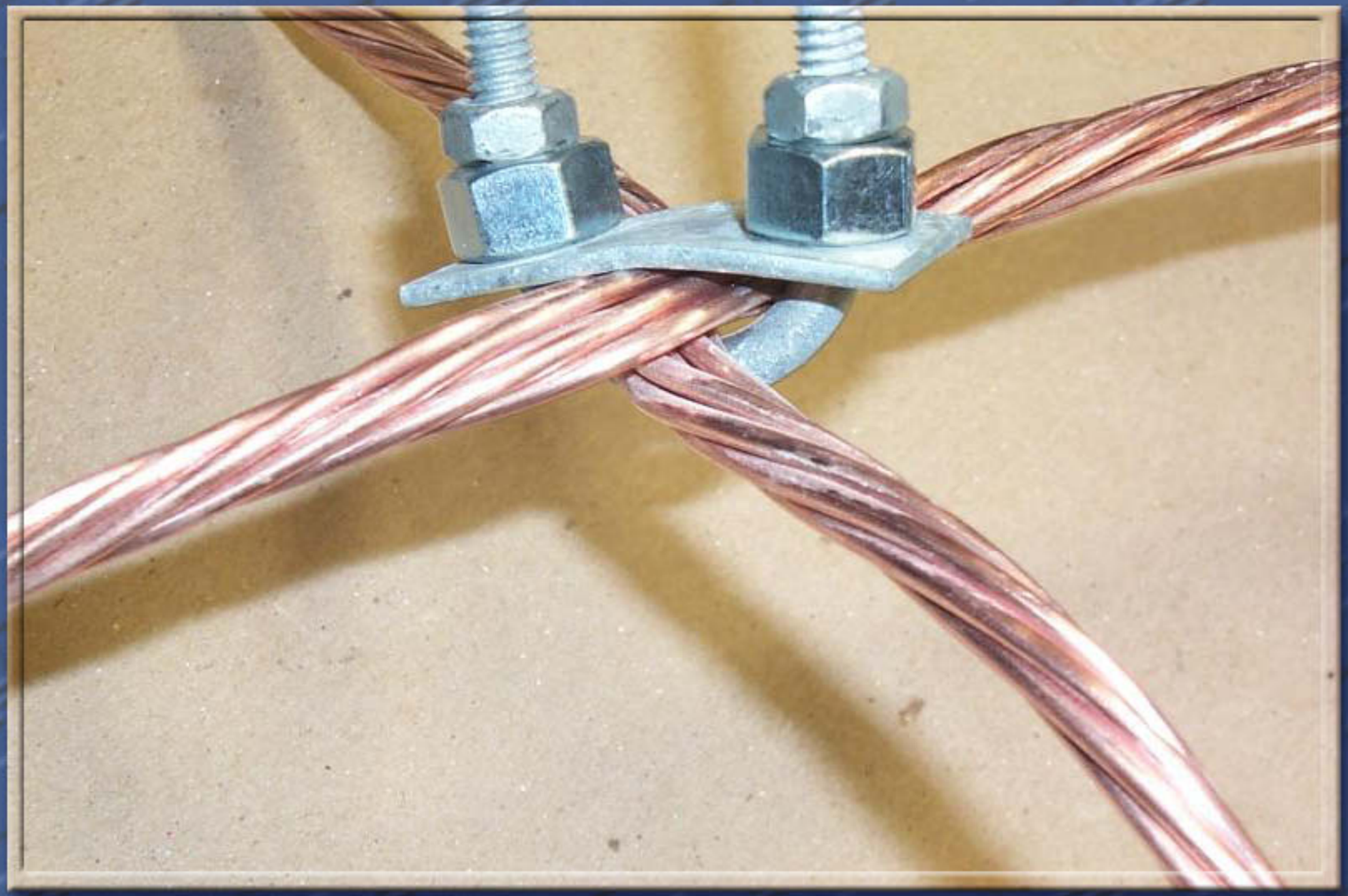
Tripping Hazard from Extension Cord to Tree on City Street

Damaged Conduit Body in Alleyway

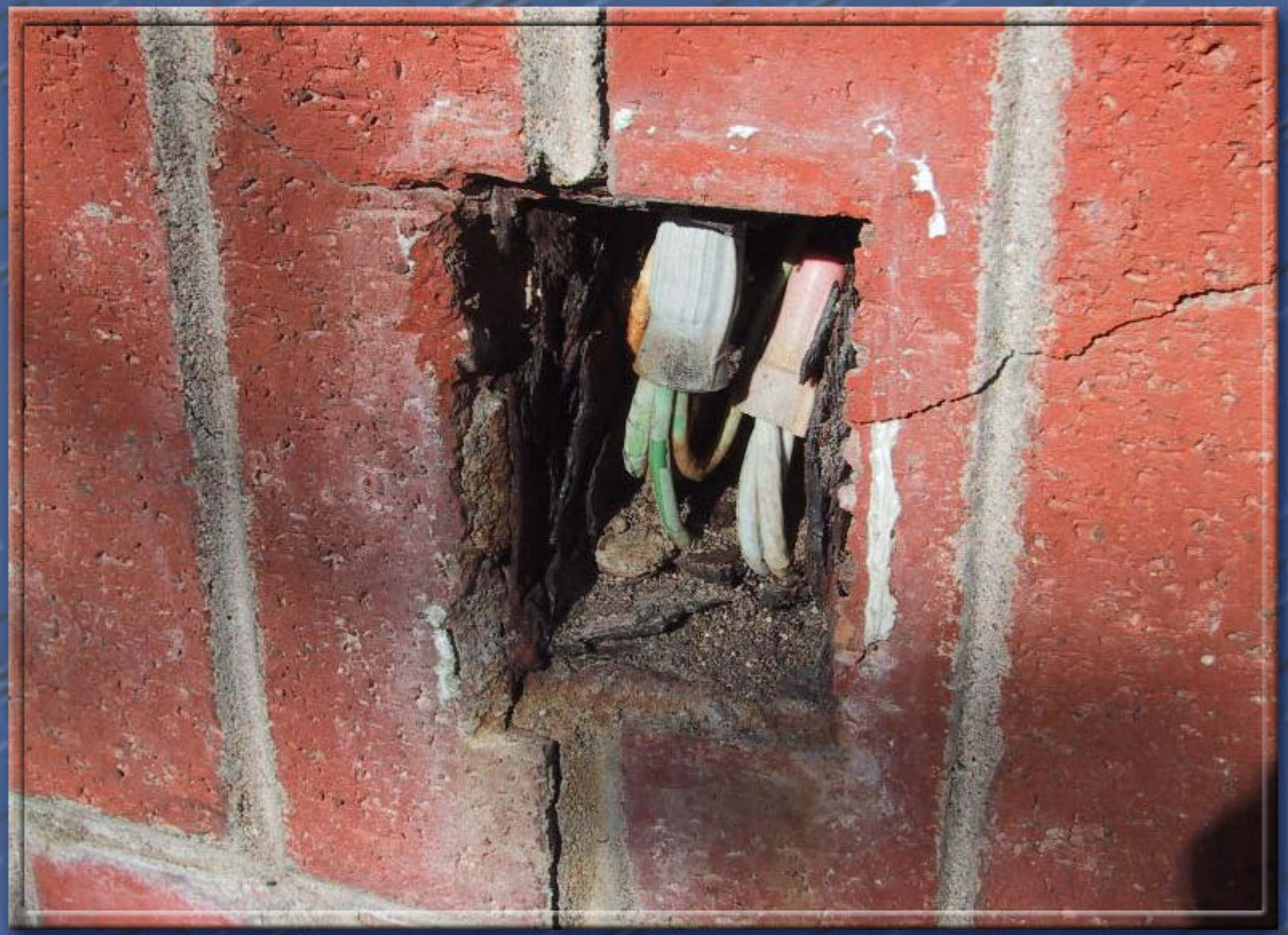
Panel Directory Not Properly Completed



Foreign Pipe Directly Over Panelboard

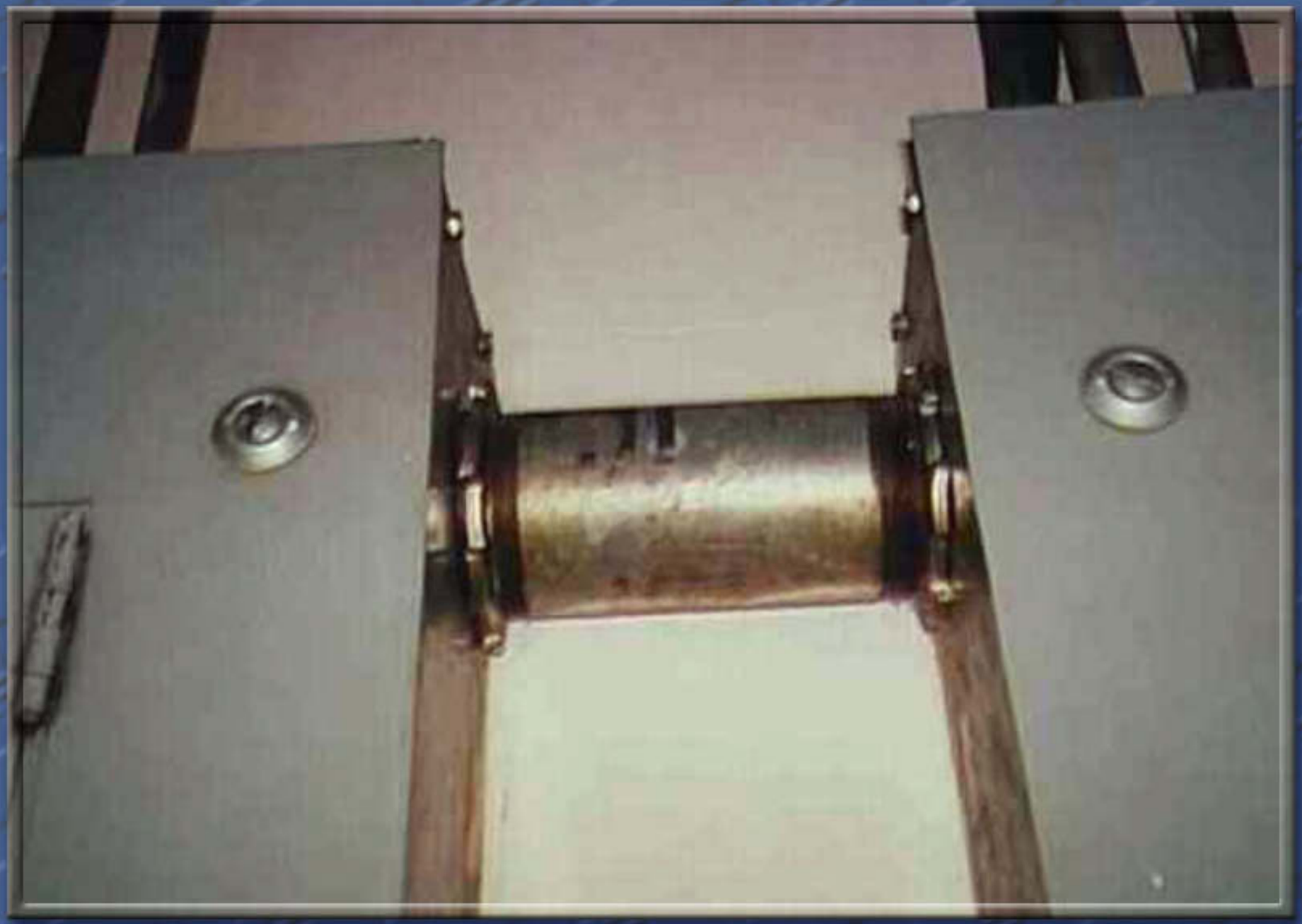


Use of Improper Fitting



Missing Plate at Splices in Outdoor Junction Box

Damaged Underground Liquidtight Flexible Metal Conduit



Loose Locknuts at Nipple

Improper Connection at Ground Rod and Subject to Damage

Storage in Front of Electrical Equipment in Hotel

Connection Loose and Not Secure

Raceways Used to Support Cables and Cords

NFPA 70-E Update 2004 Edition

DOE Electrical Safety Conference

Las Vegas **July 27, 2004**

Changes to NFPA 70E for the Seventh Edition

Allen Bingham
Bingham Consultants

Principle Member NFPA 70E Committee

History of NFPA 70E

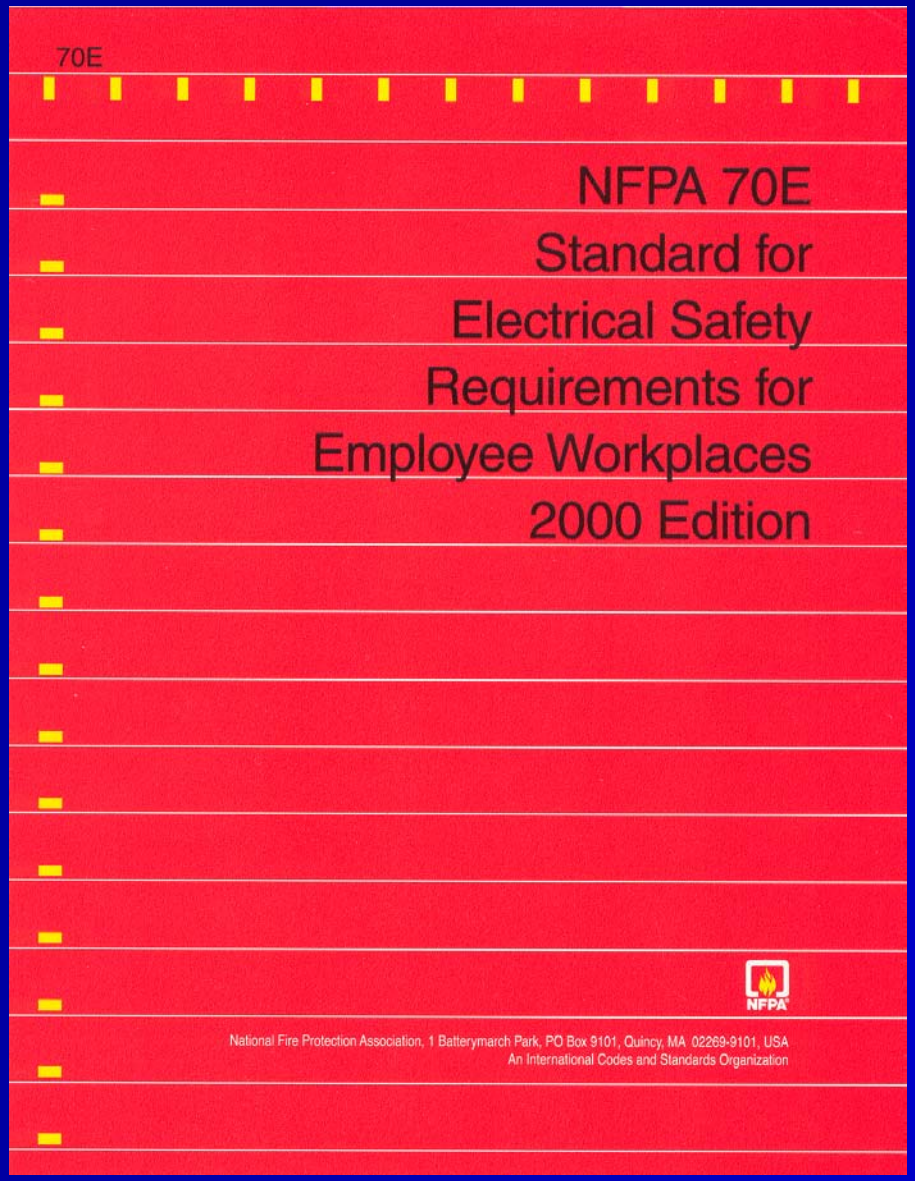
NFPA 70E
Standard for Electrical Safety Requirements for Employee Workplaces

First Edition published in 1979

History of NFPA 70E (cont'd)

NFPA 70E Committee was appointed in 1976.

Purpose: To assist OSHA in preparing electrical safety standards


70E
NFPA 70E
Standard for
Electrical Safety
Requirements for
Employee Workplaces
2000 Edition
NFPA
National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101, USA
An International Codes and Standards Organization

About NFPA 70E

This discussion covers changes made for the Seventh Edition.

Sample Calculations For Arc Flash Hazard

Pre-ROP Meeting

- Review *Manual of Style* Issues
- Receive reports from Task Groups
- Identify any additional Task Group work

Pre-ROP Task Groups

- Part I Task Group
- PPE Task Group
- Construction Task Group

ROP Meeting

173 proposals were evaluated.

- 72 accepted (42%)
- 38 accepted in principle and/or in part (22%)
- 62 rejected (36%)

ROC Task Groups

- Arc Flash Task Group
- Reorganization Task Group
- FPN Task Group

ROC Meeting

134 comments were evaluated

- 34% accepted
- 28% accepted in principle and/or in part
- 35% rejected

Format Change

- Follow the NEC Manual of Style

The Table of Contents is included in the handout.

Name of Standard

Old

Standard for Electrical Safety Requirements for Employee Workplaces

New

Standard for Electrical Safety in the Workplace

NFPA 70E

Standard for Electrical Safety in the Workplace

nec®

NFPA®

2004 Edition

Part I

Part IV

Part II

Part III

Changes to the Introduction

Definitions revised:

- Prohibited approach boundary
- Limited approach boundary
- Restricted approach boundary
- Flash protection boundary

Definitions modified to correlate with 2002 NEC

- Energized
- Live Parts

Definitions added to enhance clarity

- Flash Protection Boundary
- Incident energy
- Flame resistant (FR)
- Arc rating
- Flash hazard analysis

Safety-Related Work Practices Protective Strategies

- Reorganization Task Group
- Electrically safe work condition
- Training
- Planning the work
- Protective equipment

Electrically Safe Work Condition

- This is first-level protective strategy.
- No electrical hazard exists.
- The source of electrical energy is completely removed.
- Electrical energy cannot reappear.

Training

- This is second-level protective strategy.
- Train to understand the following:
  - Electrical hazards
  - Personal limitations
  - Authorization requirements
  - Approach boundaries
  - Characteristics of protective equipment

Plan the Work

- This is third-level protective strategy:
  - Consider each discrete step.
  - Discuss the plan with other people.
  - Use a minimum number of people.
  - Implement the plan without variation.
  - Stop the work at each unexpected condition; re-plan the work.

Protective Equipment

- This is fourth-level protective strategy:
  - Protection from shock/electrocution
  - Protection from thermal hazard
  - Protection from flying parts and pieces
  - Protection from blast

Multi-Employer Relationship

- More that one employer may be responsible
- Requires sharing information about
  - Procedures
  - Hazards
  - Protective clothing
- Requires a meeting with documentation

Article 110

- Purpose
- Responsibility
- Multi-employer relationships
- Training Requirements
- Electrical Safety Program

Article 120—Electrically Safe Work Condition

- 120.1—Necessary steps
- 120.2—Working near locked circuits
- 120.3—Temporary protective grounds

Article 130—Working on or near Live Parts

- 130.1—Justification for the work
  - Energized work permit
- 130.2—Approach boundaries
  - Table 130.2—Shock boundaries
- 130.3—Flash hazard analysis

Article 130—Working on or near Live Parts (cont'd)

- 130.4—Test instruments and equipment
- 130.5—Overhead lines
- 130.6—Other precautions
- 130.7—Personal and other protective equipment
- Table 130.7—Standards on protective equipment

Article 130—Working on or near Live Parts (cont'd)

- Table 130.7(C)(8)—Standards on protective equipment
- Table 130.7(C)(9)(a)—Hazard/risk category classifications
- Table 130.7(C)(10)—Protective clothing and equipment matrix
- Table 130.7(C)(11)—Protective clothing characteristics

Energized Electrical Work Permit

- Analysis of infeasibility to deenergize
- Requires Written Authorization
- Requires the worker to:
  - identify and understand the hazards
  - be properly trained
  - wear proper PPE
  - restrict access to unqualified persons
  - complete a Job Briefing

Selection of Personal Protective Equipment

- Standards for equipment updated and added
- Hazard/Risk Classification Table
- PPE Matrix
- Clothing characteristic table
- Clothing characteristics

Chapter 2—Safety Related Maintenance Requirements

This chapter includes Articles 200 through 250.

There were no changes to requirements in this chapter.

Chapter 3—Safety Requirements for Special Equipment

This chapter includes articles 300 through 340.

There were editorial changes to requirements in this chapter.

Chapter 4—Installation Safety Requirements

This chapter comprises information extracted from the NEC.

There were significant changes necessary to update requirements covered in the 2002 NEC. However, they will not be discussed today.

Annex A

Reserved

Annex B—Reference Publications

This annex provides a listing of all publications that are used as source information for content of the standard.

Annex C—Limits of Approach

- Preparation for approach
- Safe approach distance—Unqualified persons
- Safe approach distance—Qualified persons
- Basis for shock approach distance

Annex D—Sample Calculations of Incident Energy

- Arc flash boundary
- Basic Lee Equations
- Basic Doughty Equations
- Basic IEEE 1584 Equations

Annex E—Electrical Safety Program

- Typical program principles
- Typical program controls
- Typical safety procedures

Annex F—Hazard/Risk Evaluation

This annex provides a sample hazard/risk evaluation procedure.

Annex G—Sample Lockout/Tagout Procedure

This annex provides a sample lockout/tagout procedure that could be modified and used by a company.

Annex H—Simplified Two-Category Protective Clothing System

This annex provides a sample protective clothing scheme that illustrates how a protective clothing system could be organized for ease of administration.

Annex I—Job Briefing and Planning Checklist

This annex provides a sample checklist that a company could use as a beginning to develop its own checklist.

Annex J—Energized Electrical Work Permit

This annex provides a sample permit that a company could use to justify and authorize work on energized conductors.

Annex K—General Categories of Electrical Hazards

This annex provides a a discussion of currently recognized hazards associated with electrical energy.

Annex L—Typical Application of Safeguards in the Cell Line Working Zone

This annex provides a discussion of typical safeguards that may be necessary for work adjacent to electrolytic cells.

Annex M—Cross Reference Index

- This annex provides a cross reference for 2000 edition versus the 2004 edition of NFPA 70E

Plans for the future of NFPA 70E

Fire Protection Research Foundation

Technical committee asked the foundation to do the following:

- Determine the spectral intensity of arc energy.
- Correlate result with ASTM F-18 Series.
- Determine the explosive (blast) effects.
- Determine method to protect personnel.

Future Direction Task Group

The mission of this new task group is to provide recommendations to guide the future direction of NFPA 70E.

Tasks to Be Done

- Identify electrical safety issues that are not now addressed by the standard.
- Identify new protective strategies.
- Provide guidance on how to improve the effectiveness of the standard.

OSHA Activity

- Compliance training
  - Ohio training
  - Wisconsin Training
  - Region 1 Training
- OSHA VPP
  - Region 5 Presentation
  - Region 1 Presentations
  - VPP Involvement

Questions, Comments ???

Arc Flash Hazard Calculations
Why? How? What's Next?

Daniel Doan
DuPont Engineering

Agenda

- Why do a study?
  - A chemical company's experience
  - A refining company's experience
- How we did a study
- System upgrades to reduce exposure
- IEEE 1584
  - P1584 Working Group activities

One Company's "Save"

- Arc Flash Study completed Nov 2001
- 183 pieces of equipment
  - 55 Distribution Points (12KV, 69KV)
  - 30 MV Points (2.3KV)
  - 98 LV Points (480V)
- 4 conditions
  - 1 or 2 Main Transformers On Line
  - Loops Closed or Open
- Varied Results from Calculations

One Company's "Save"

- Results:

Voltage	Incident Energy (cal/sqcm)		
	Min	Median	Max
69 KV	41	41	41
12 KV	2.3	10	133
2.4 KV	0.3	1.3	21
480 V	0.1	6.9	102

- Equipment labeled
- PPE determined and purchased
- Workers Trained

One Company's "Save"

Incident:

- October 8, 2003 2:45 AM
- 480V Substation
- Swapping breaker with rebuilt unit
- Ground stab bent, contacting A phase
- When energizing CB, 3-phase fault
- 2 primary fuses opened

October 8, 2003

One Company's "Save"

From Study:

- 38,900A bolted fault current
- 24,200A arcing fault current
- Primary fuse opens in 0.8 seconds
- Incident Energy (IE) of 88 cal/cm^2 at 18" working distance

From Incident Report:

- 28" measured distance, worker to arc
- Estimated IE of 50 cal/cm^2

One Company's "Save"

Outcome:

- First Aid Case – minor burn on face from hot (loose) faceshield
- 2nd person not hurt

Learnings:

- Lost-workday case was prevented
- Workers use PPE during off-shifts
- Hazard Analysis and PPE costs were small compared to possible cost of injury

Phase 1

Through December 2001

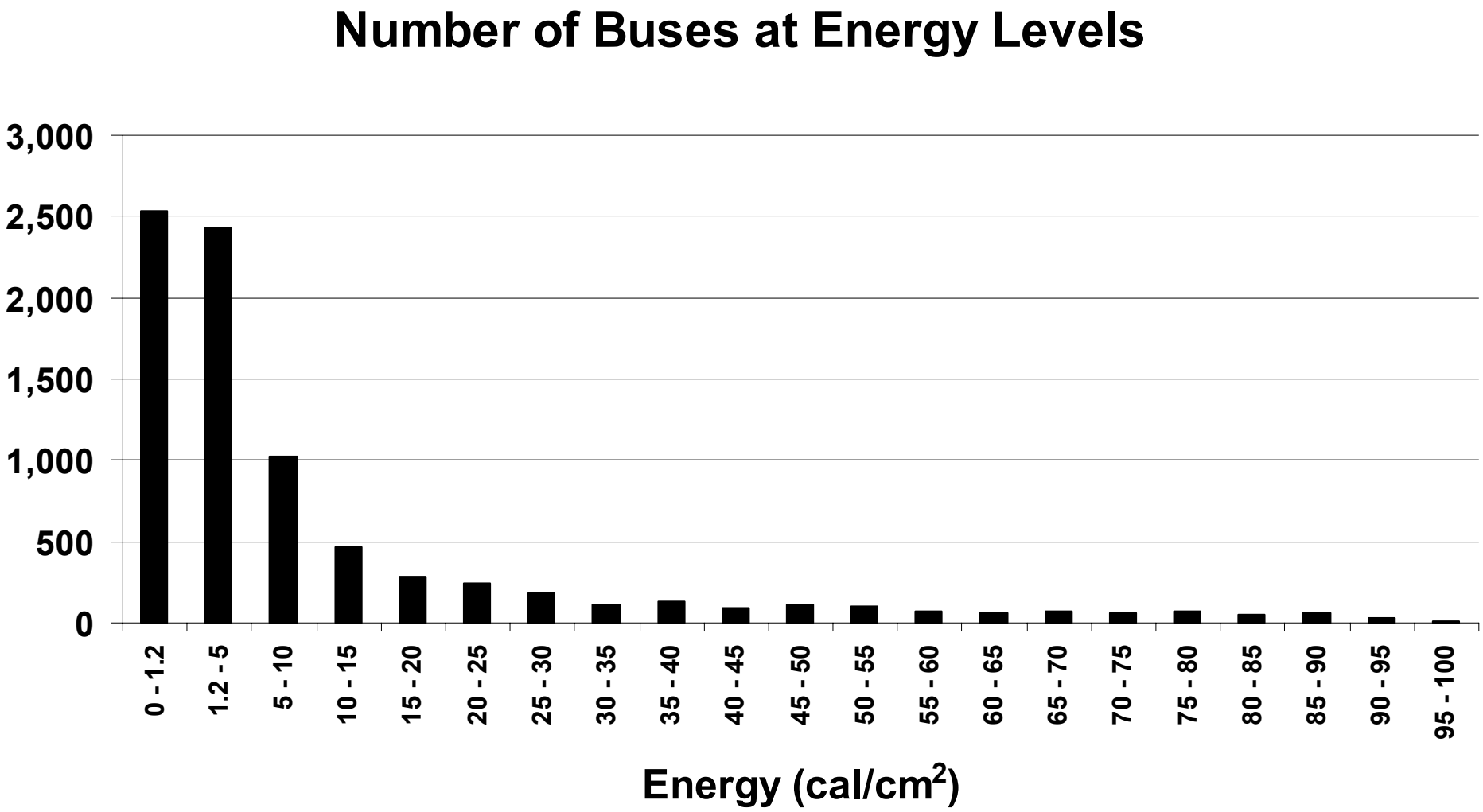
Using calculations from Doughty, et al (NFPA70E-2000 App. B)

33 Sites Studied
- 8,400 potential fault points
- 925,000 exposures annually

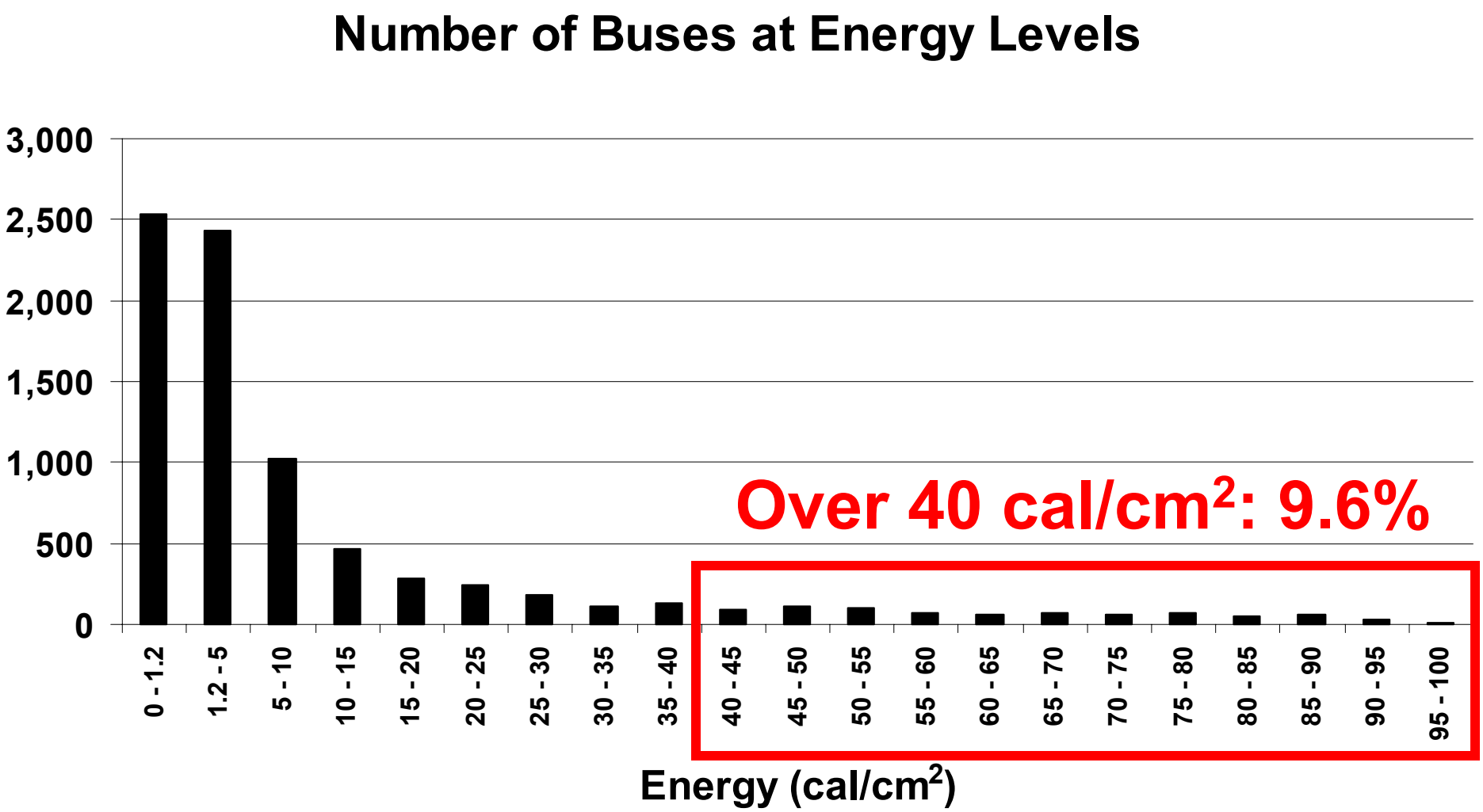
IEEE Paper:

D.R. Doan and R.A. Sweigart, "A Summary of Arc Flash Hazard Calculations", IEEE Transactions on Industry Applications, Vol 39 Issue 4, Jul/Aug 2003, pp.1200-1204.

Phase 1


Number of Buses at Energy Levels
3,000
2,500
2,000
1,500
1,000
500
0
0 - 1.2
1.2 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 85
85 - 90
90 - 95
95 - 100
Energy (cal/cm2)

Phase 1


Number of Buses at Energy Levels
3,000
2,500
2,000
1,500
1,000
500
0
0 - 1.2
1.2 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
70 - 75
75 - 80
80 - 85
85 - 90
90 - 95
95 - 100
Over 40 cal/cm²: 9.6%
Energy (cal/cm²)

Phase 2

Through December 2003

30 Additional Sites Studied

Some using IEEE 1584 equations

Learned more about Arc Flash Incident Energy and Exposures

IEEE Paper:

D.R. Doan and H.L.Floyd, “Comparison of Methods for Selecting Personal Protective Equipment for Arc Flash Hazards”, IEEE Transactions on Industry Applications, Vol 40 Issue 4, Jul/Aug 2004.

Phase 2

Results of a Cost Comparison of Different Methods of Arc Flash Analysis

Method	PPE	Analysis	Injury	Total
No PPE	0	0	20,800	20,800
Cotton LS Shirt	0	50	8,100	8,150
Multi-layer FR	1,570	100	6,150	7,820
Detail Analysis	835	2,000	150	2,985

(all in US$1000)

Phase 2: Study Results at Large Site

Equipment	NFPA 70E PPE Class						
	0	1	2	3	4	5	6
	<1.2	4	8	25	40	100	>100
PPs 240V-600V	3	0	4	5	1	1	
600V MCCs	85	19	31	61	3		3
600V S/G	5	1	2	2		2	41
600V S/G loads	90	17	2				
Other 600V Eqpt	18	11	11	17	5	1	1
MC S/G >1KV	6	30	11	16			
Other Eqpt >1KV	2	10	5	2			
Total	209	88	66	103	9	4	45
	40%	17%	13%	20%	2%	1%	9%

Corporate COT

- Critical Operating Task
- Based on Safety Goal of “Zero Injuries”
- Detailed Analysis will be complete by end of 2004
- Results implemented for all sites by end of 2005

Agenda

- Why do a study?
  - A chemical company's experience
  - A refining company's experience
- How we did a study
- System upgrades to reduce exposure
- IEEE 1584
  - P1584 Working Group activities

Large US Refining Company Incident Energy Calculation Results

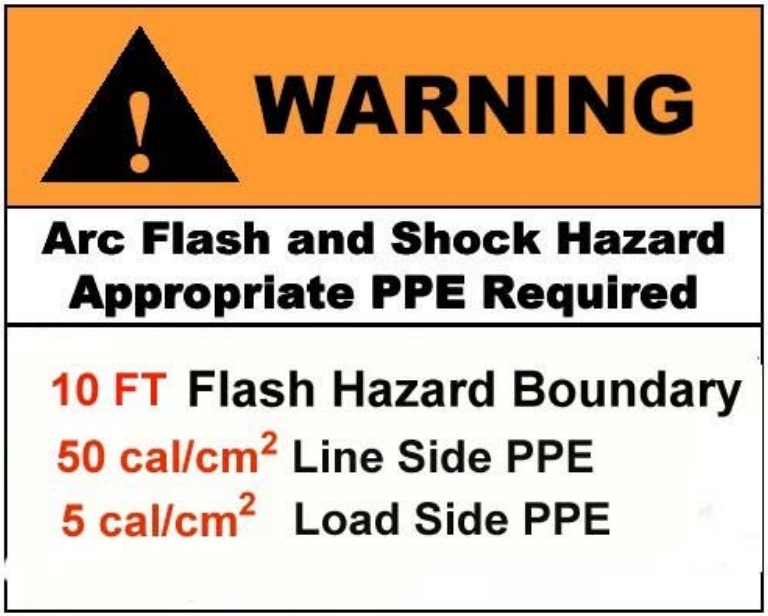
- Data represents arc flash calculation results from 6 US refineries, 2500 buses, with voltage ranging from 13.8kV to 208V
- Although this company has standardized on IEEE Std 1584, results represent mixture of Doughty, Lee and IEEE Std 1584 methods
- Calculation tools include
  - IEEE spreadsheet based on Doughty and Lee methods
  - IEEE spreadsheet based on IEEE Std 1584 methods
  - 3rd party power systems analysis software

Large US Refining Company Incident Energy Calculation Results

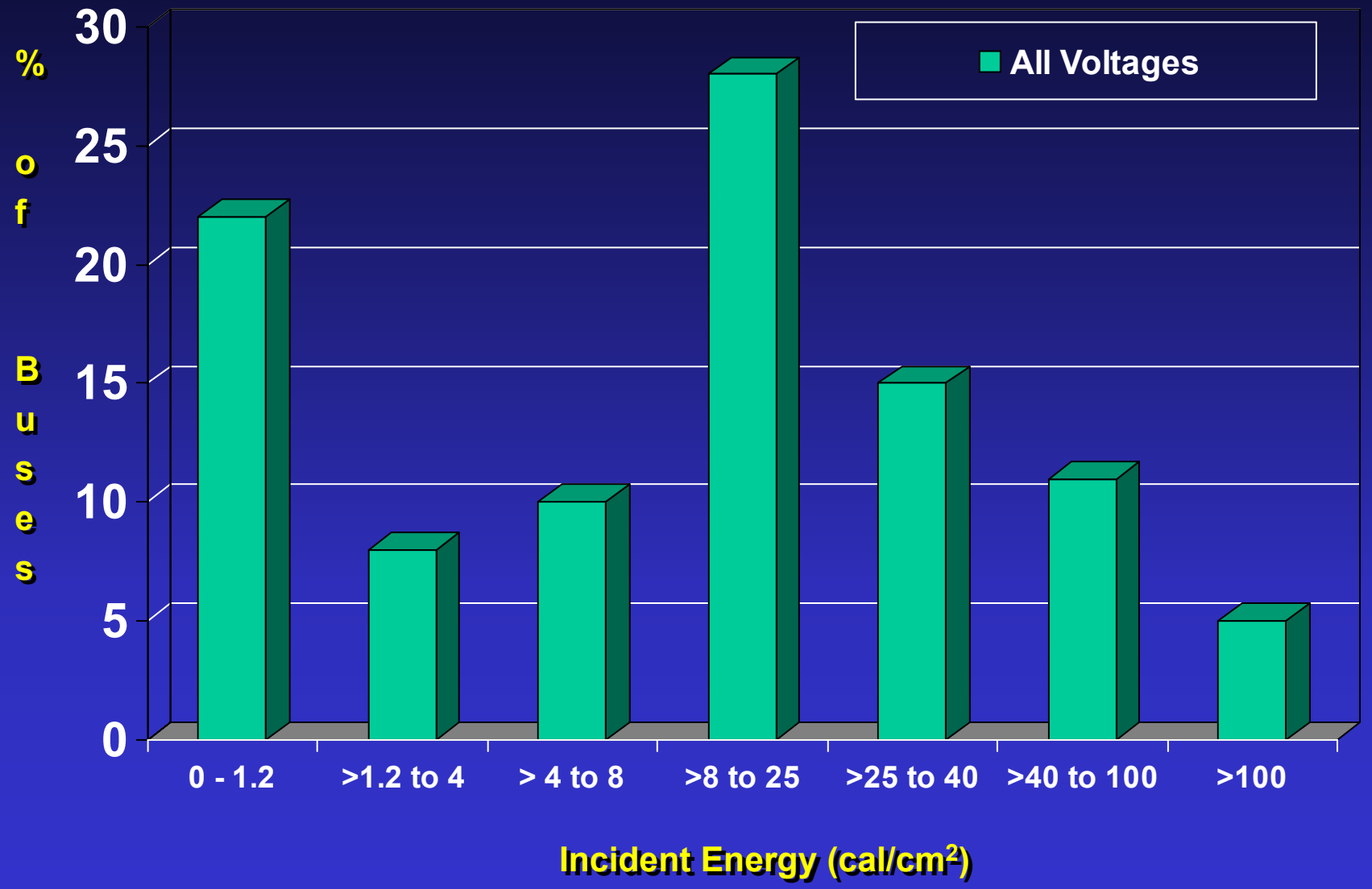
- Incident energy calculations vs. NFPA 70E Table 3-3.9.1
  - Calculations conducted in 2000 at one refinery showed tremendous variability in available incident energy at all voltage levels
  - Due to this variability, company decided to perform incident energy calculations at each location and label switchgear, motor control centers, and panelboards with the level of protection (based on calculated incident energy) and the flash protection boundary

Large US Refining Company Incident Energy Calculation Results

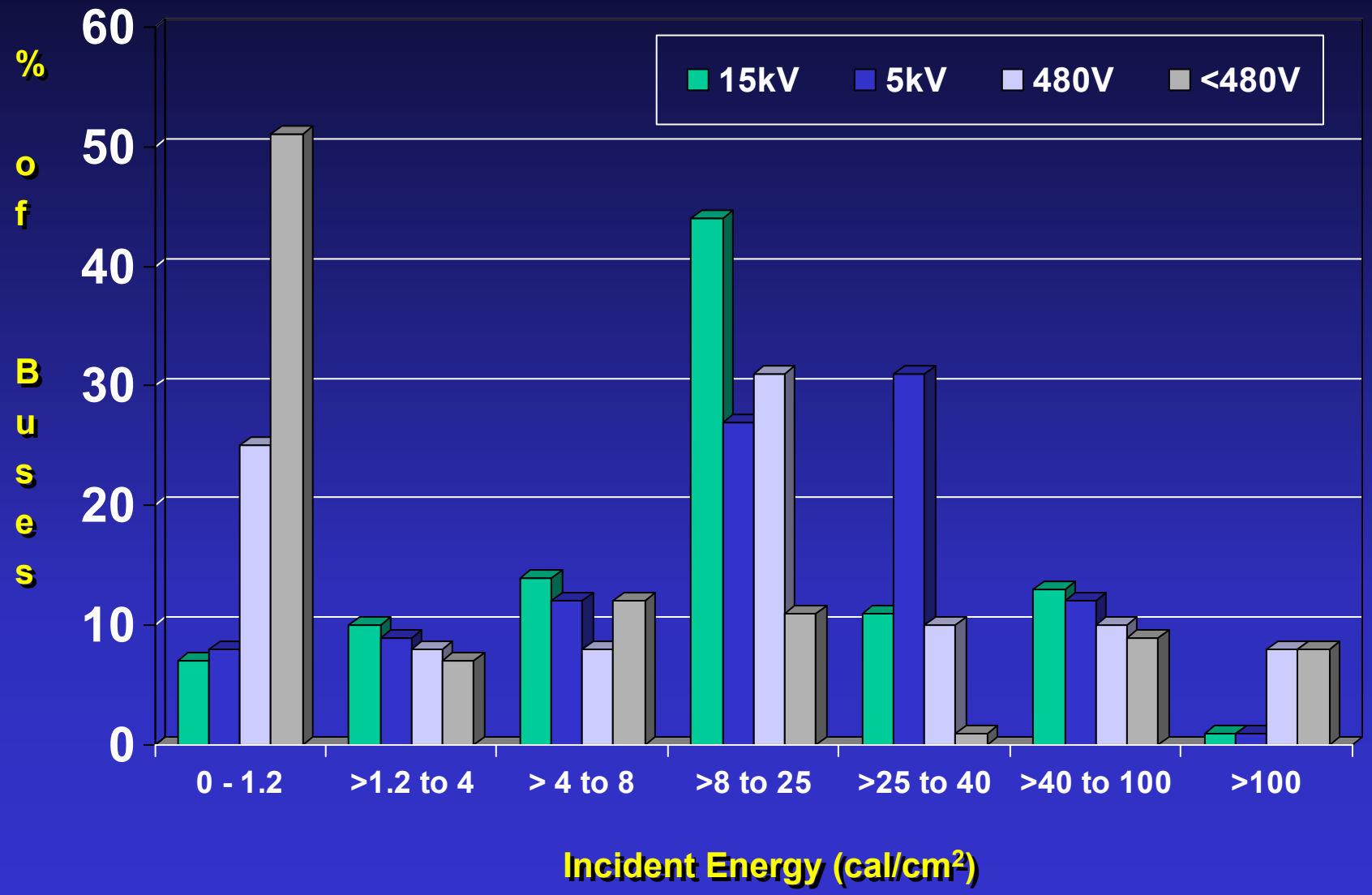
Sample Label



Large US Refining Company Incident Energy Calculation Results



Large US Refining Company
Incident Energy Calculation Results



Large US Refining Company Incident Energy Calculation Results

- For incident energies >100 cal/cm^2, investigating methods for reducing incident energy such as
  - Modifying protective device settings
  - Increasing distance by remote operation/racking
  - Changing equipment operating, maintenance, and switching procedures
- Modifying company standards so that new installations do not exceed 40 cal/cm^2 exposure
- Modifying company standards to utilize arc-resistant switchgear where available

Agenda

- Why do a study?
  - A chemical company's experience
  - A refining company's experience
- How we did a study
- System upgrades to reduce exposure
- IEEE 1584
  - P1584 Working Group activities

Doing an Arc Flash Study

- Process
  - Gather Data
  - Short circuit model
  - Arc Flash calculations
- Issues
  - More info needed!
  - Long time exposures
  - High energy points
- Solutions
  - Data Review
  - PPE Selection
  - Labeling and Training

Process

- Gathering Data
  - Get system single line
  - Get utility short circuit data
  - Study operating conditions, such as Normal operation; Loops closed; Transformers in parallel; Dual Feeds
  - Find details on transformers, buses, substations, and feeder cables

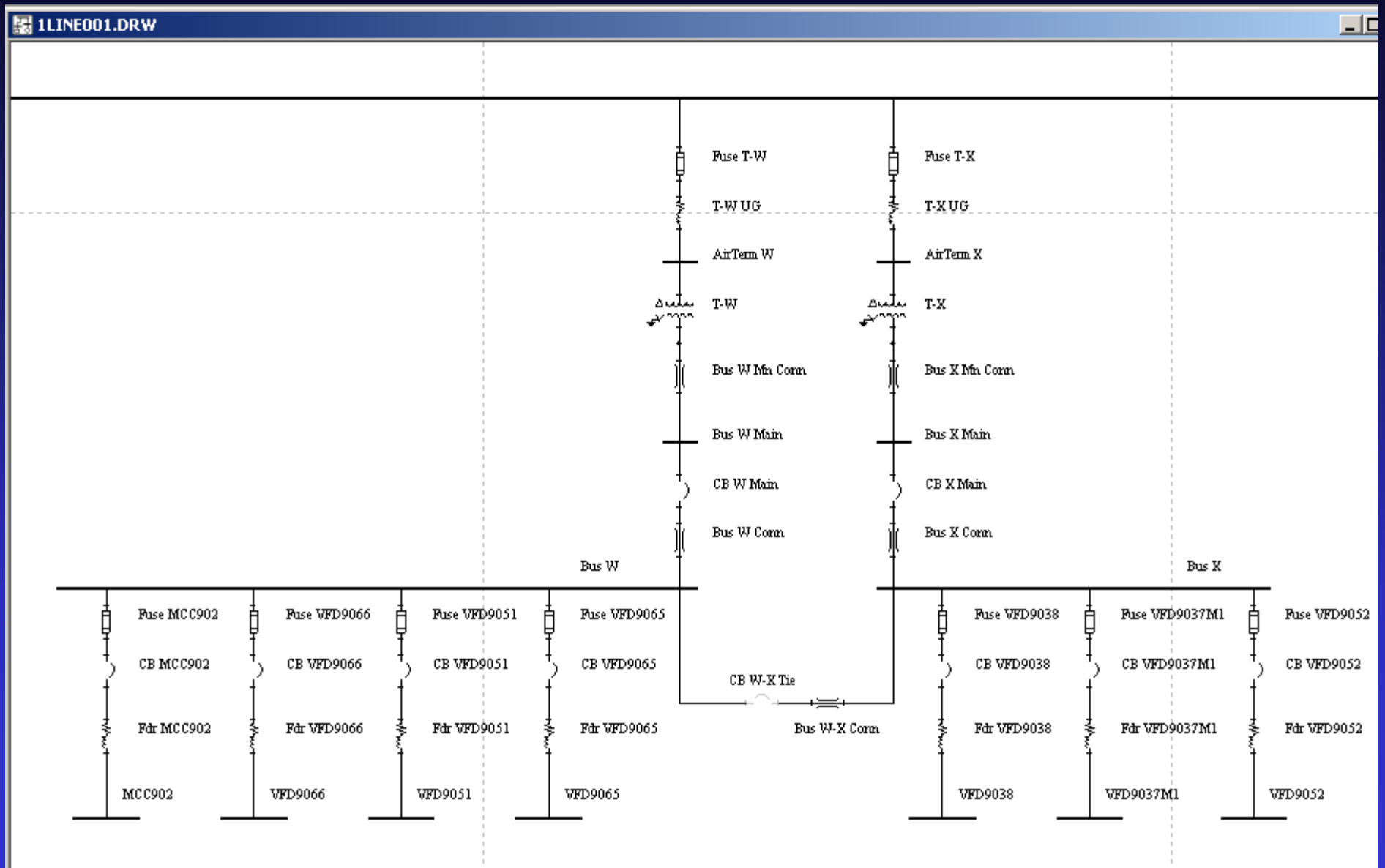
Process

- Gathering Data
  - Get manufacturer, model, trip unit, and settings of circuit breakers
  - Get manufacturer, type and size of fuses
  - Get information on motors > 100HP
  - Get equipment type (MCC, panel, or switchgear)
  - Determine grounding method
  - Determine Working Distance for the task being studied at each piece of equipment

Process

- Short Circuit Model
  - Enter system information
  - Run model to get values for 3-phase short circuit current value: I_{BF} (ANSI) or I_K (IEC)

Example System Model



Process

- Arc Flash Calculations
  - Enter Working Distance, Grounding Method, and Equipment type for each point
  - Review very high energy points (> 40 cal/cm^2) for errors of data input
  - Review very low energy values (< 6 cal/cm^2) on LV switchgear (usually high energy) for errors

Example Study Output

Arc Flash Evaluation

Detail View | Summary View | Bus Detail... | Bus Label... | Re-Run Study | Options... | PPE Table...

	Bus Name	Protective Device Name	kV	Bus Bolted Fault (kA)	Prot Dev Bolted Fault (kA)	Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Requirec
108	MCC270 SCCP1	CBMCC270 SCCP1	0.48	8.51	8.51	5.72	0.025	0.000	Yes	PNL	25	10	18	0.45	Class 0,
109	MCC270 SCCP2	CBMCC270 SCCP2	0.48	8.78	8.78	5.87	0.025	0.000	Yes	PNL	25	10	18	0.47	Class 0,
110															
111	MCC28	CB MCC28	0.48	29.13	26.40	14.81	0.025	0.000	Yes	PNL	25	20	18	1.41	Class 1, Coveralls
112	MCC28 NthChill	FsMCC28 NChill	0.48	11.21	11.21	7.23	0.01	0.000	Yes	PNL	25	7	18	0.23	Class 0,
113	MCC28 Polysoy	FsMCC28 Plysoy	0.48	3.53	3.53	2.69	0.038	0.000	Yes	PNL	25	7	18	0.26	Class 0,
114	MCC280	CB MSG1 1D	0.48	23.93	23.93	13.82	0.025	0.000	Yes	PNL	25	18	18	1.18	Class 0,
115															
116	MCC29	CB MCC29	0.48	31.49	29.54	16.39	0.025	0.000	Yes	PNL	25	21	18	1.52	Class 1, Coveralls
117	MCC29 CtrChill	FsMCC29 CChill	0.48	10.28	10.28	6.71	0.01	0.000	Yes	PNL	25	6	18	0.22	Class 0,
118	MCC290	CB MCC290	0.48	25.37	25.37	14.53	0.025	0.000	Yes	PNL	25	18	18	1.24	Class 1, Coveralls
119	MCC290 VFD	FsMCC290 VFD	0.48	20.03	20.03	11.87	0.01	0.000	Yes	PNL	25	9	18	0.40	Class 0,
120															
121	MCC3	Fuse MCC3	0.48	31.82	29.48	16.33	0.01	0.000	Yes	PNL	25	12	18	0.61	Class 0,
122	MCC30	CB MCC30	0.48	32.02	29.48	16.31	0.025	0.000	Yes	PNL	25	21	18	1.54	Class 1, Coveralls
123	MCC31	CB MCC31	0.48	30.61	29.64	16.51	0.025	0.000	Yes	PNL	25	20	18	1.48	Class 1, Coveralls
124	MCC310	CB MCC310	0.48	22.17	22.17	12.94	0.025	0.000	Yes	PNL	25	17	18	1.10	Class 0,
125															
126	MCC310 AHU	CBMCC310 AHU	0.48	5.99	5.99	4.23	0.025	0.000	Yes	PNL	25	8	18	0.33	Class 0,
127	MCC310 CPP1	CBMCC310 CPP1	0.48	16.96	16.96	10.30	0.025	0.000	Yes	PNL	25	15	18	0.86	Class 0,
128	MCC310 PP3	FsMCC310 PP3	0.48	17.94	17.94	10.81	0.01	0.000	Yes	PNL	25	9	18	0.36	Class 0,
129	MCC32	CB MCC32	0.48	31.13	28.38	15.77	0.025	0.000	Yes	PNL	25	21	18	1.50	Class 1,

Issues

- Long Time Exposures
  - Some points have long time exposures
  - Most IEEE 1584 testing was under 2 seconds
  - A worker would step back or be forced back from the arc
  - In areas where there is room to escape or move away, limit the maximum time
  - Conservative: 5 seconds time limit
  - Some consultants use 2 seconds

Issues

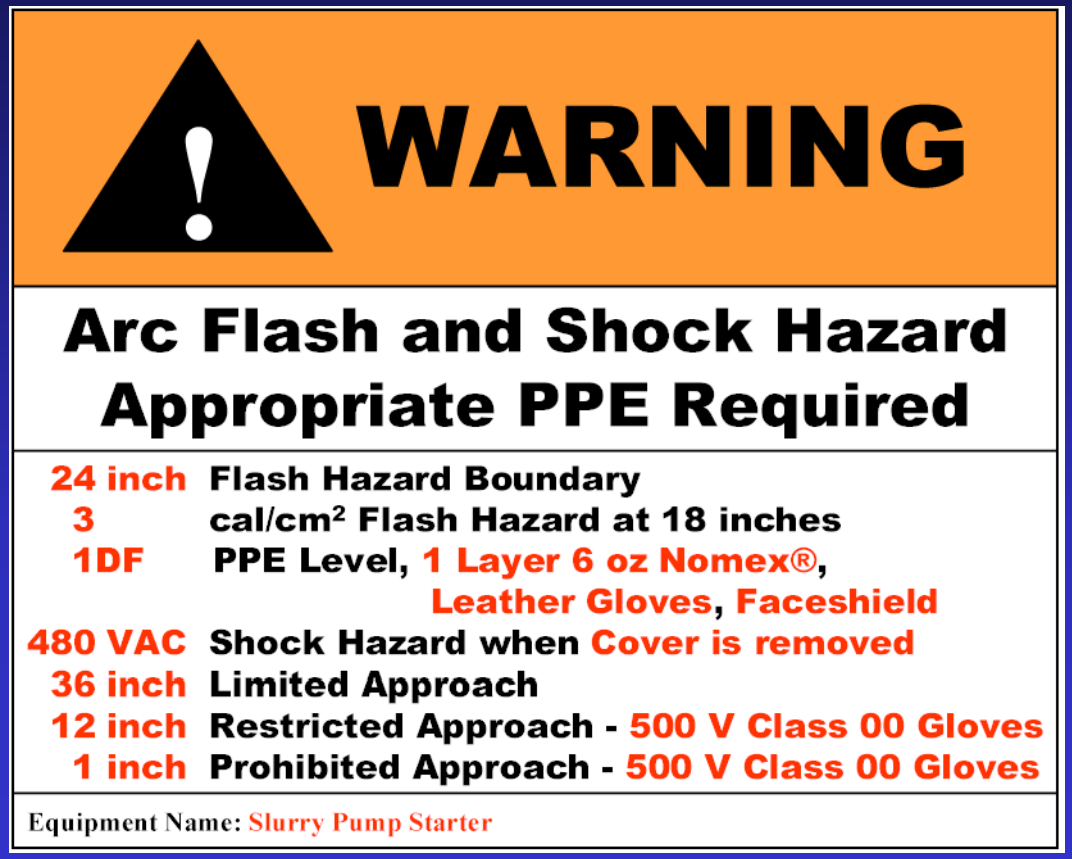
- High Energy Points
  - Primary fuse takes long time to open
  - LV circuit breaker Short Time settings too high
  - Low fault current due to long cable lengths
  - Later slides: design changes that can reduce incident energy

Using Results

- PPE Selection
  - Usually Class 1 covers majority of exposures
  - Probably need an additional heavier suit for a few exposures
  - Chose 40 cal/cm^2 suit if all exposures under 40
  - If some are over 40, try to reduce them first
  - Higher rated suits available if needed
  - NFPA 70E has guidance

Solutions

- Labeling
  - Follow ANSI Z-535



Solutions

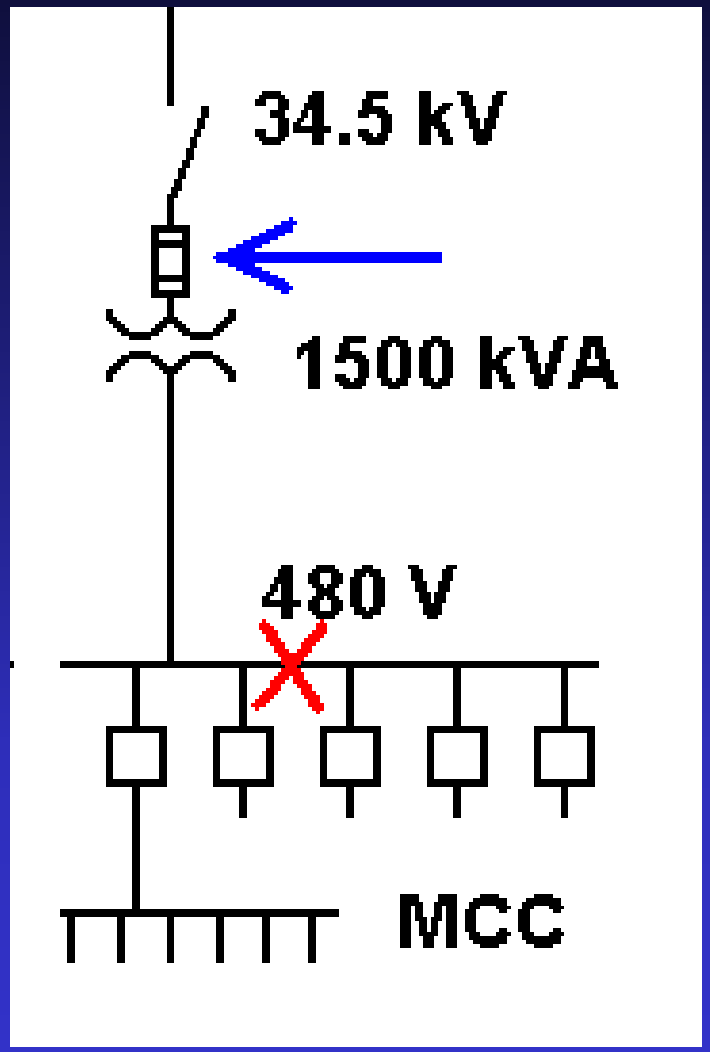
- Training
  - Training of workers is critical
  - Understanding of PPE classes
  - Understanding of tasks
  - Knowledge of hazard of tie conditions
  - Effects of other changes (tasks, equipment replacement like fuses, breaker settings)
  - Train all workers including plant operators who only do lockout switching

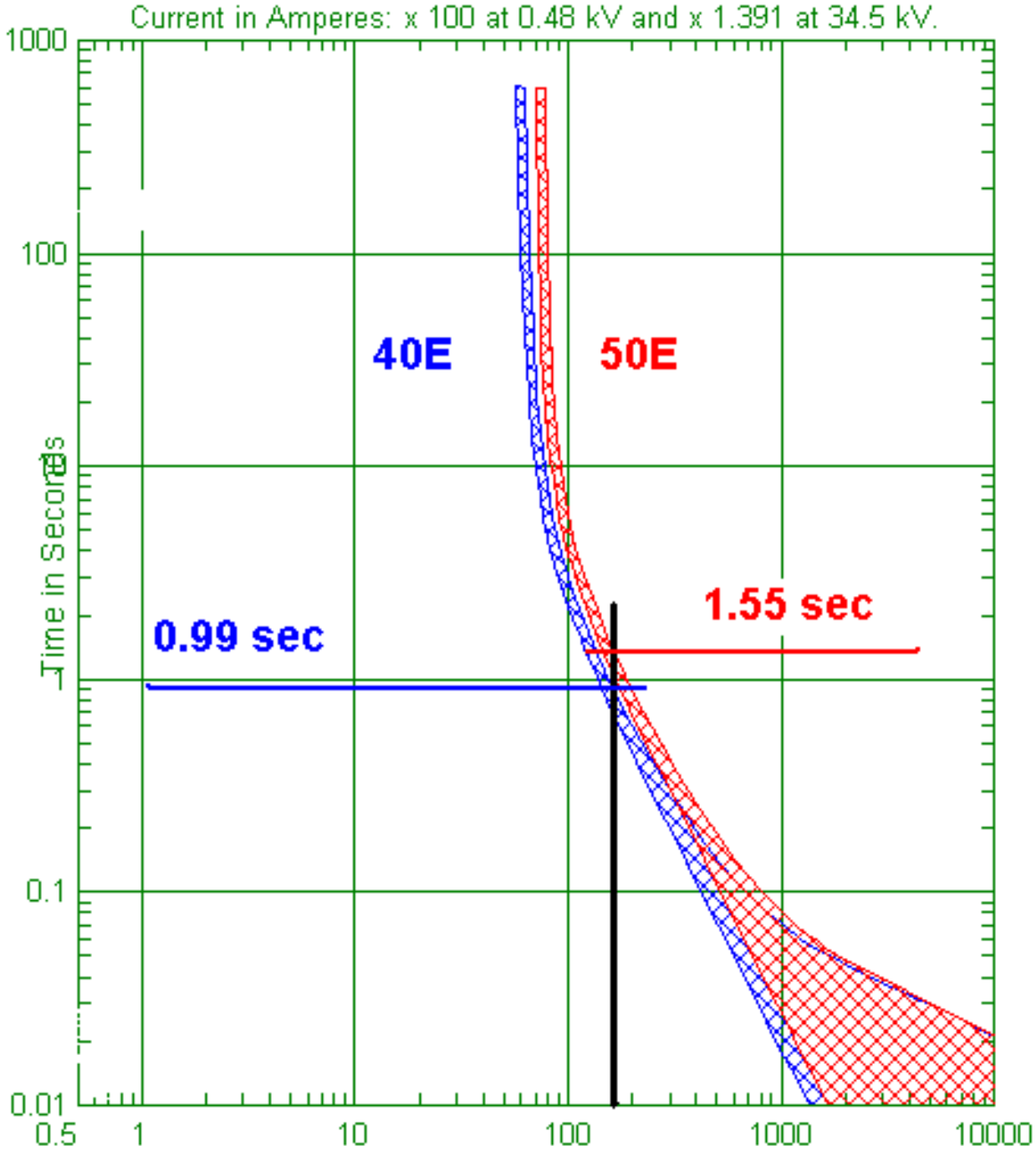
Agenda

- Why do a study?
  - A chemical company's experience
  - A refining company's experience
- How we did a study
- System upgrades to reduce exposure
- IEEE 1584
  - P1584 Working Group activities

Distribution transformers Primary Fuse Size

- 50E Fuse at 34.5 kV
  150% x FLA = 37.7A
- Bolted fault current 30kA
  Arcing fault current 15.8kA
  Working Distance 24 in.
- Energy is 53.3 cal/cm2




Current in Amperes: x 100 at 0.48 kV and x 1.391 at 34.5 kV.
1000
100
10
1
0.1
0.01
Time in Seconds
0.5
1
10
100
1000
10000
40E
50E
0.99 sec
1.55 sec

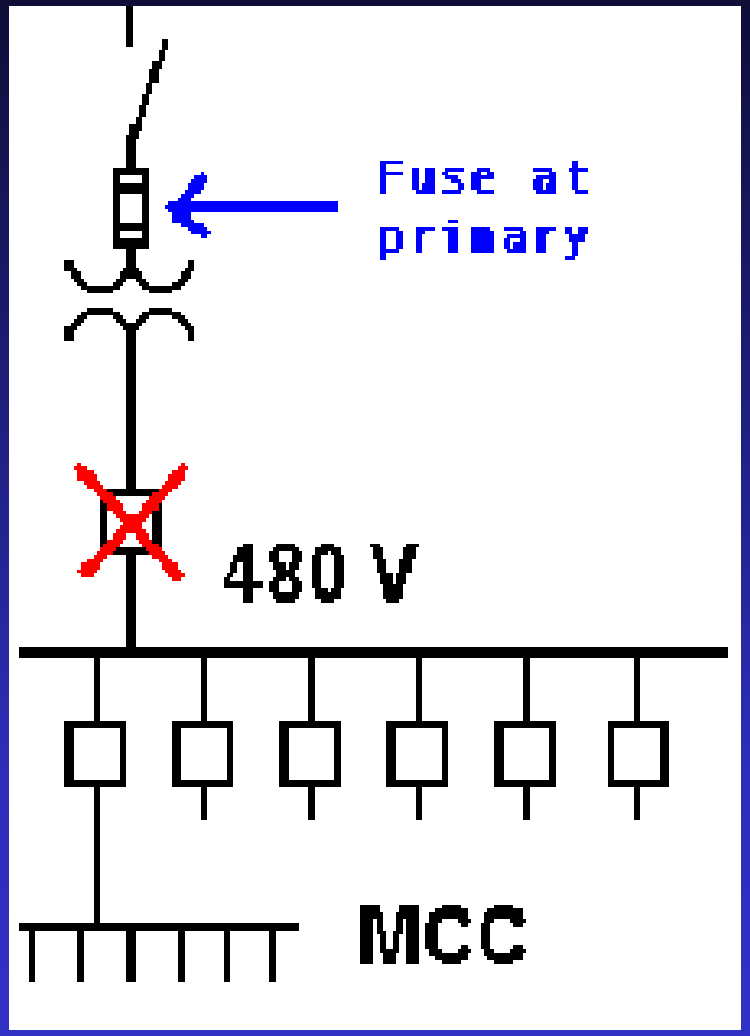
Distribution Transformer Primary Fuse Size

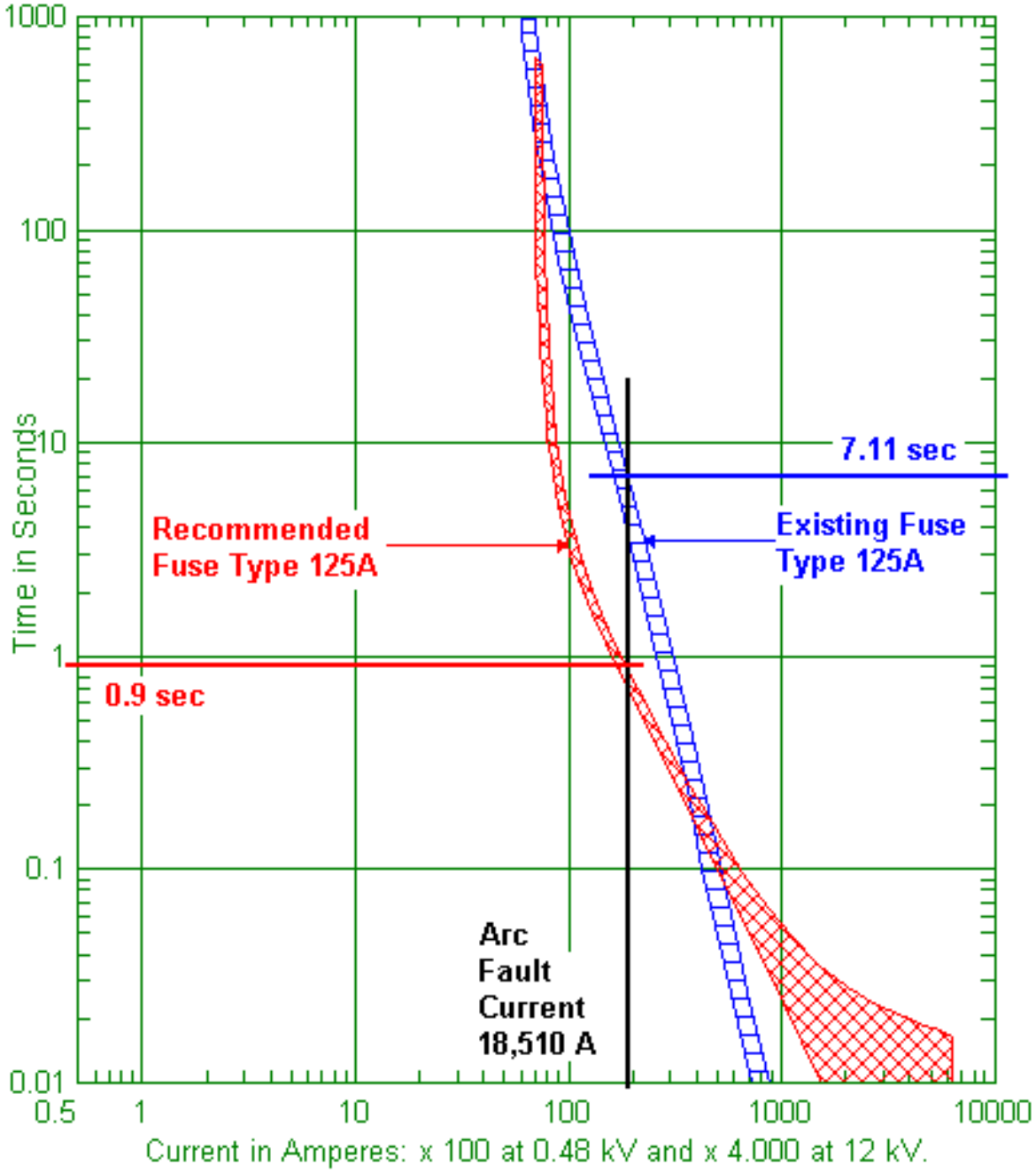
Comparison of Incident Energy

Fuse	Time	Energy	PPE
50E	1.55	53.1	5
40E	0.99	34.1	4

Distribution Transformer Primary Fuse Type

- Fault at 480 V Main Breaker
- Fuse at Transformer Primary Clears Fault
- Type of Fuse Installed - Current limiting




1000
100
10
1
0.1
0.01
Time in Seconds
0.5
1
10
100
1000
10000
Current in Amperes: x 100 at 0.48 kV and x 4.000 at 12 kV.
7.11 sec
Existing Fuse
Type 125A
Recommended
Fuse Type 125A
0.9 sec
Arc
Fault
Current
18,510 A

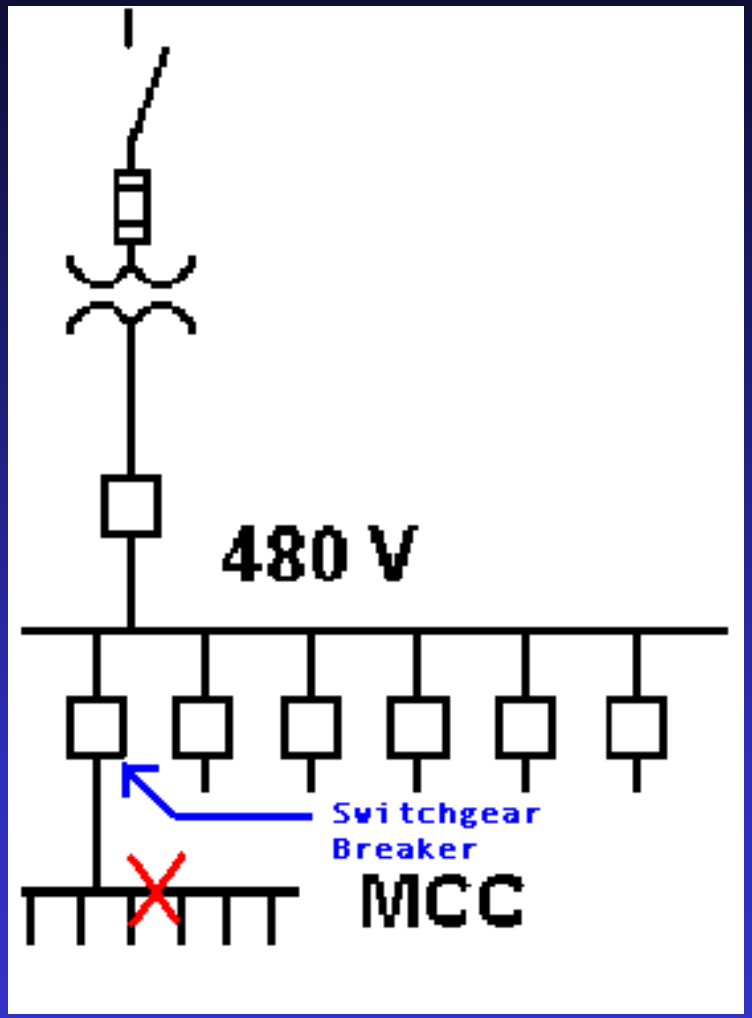
Distribution Transformer Primary Fuse Type

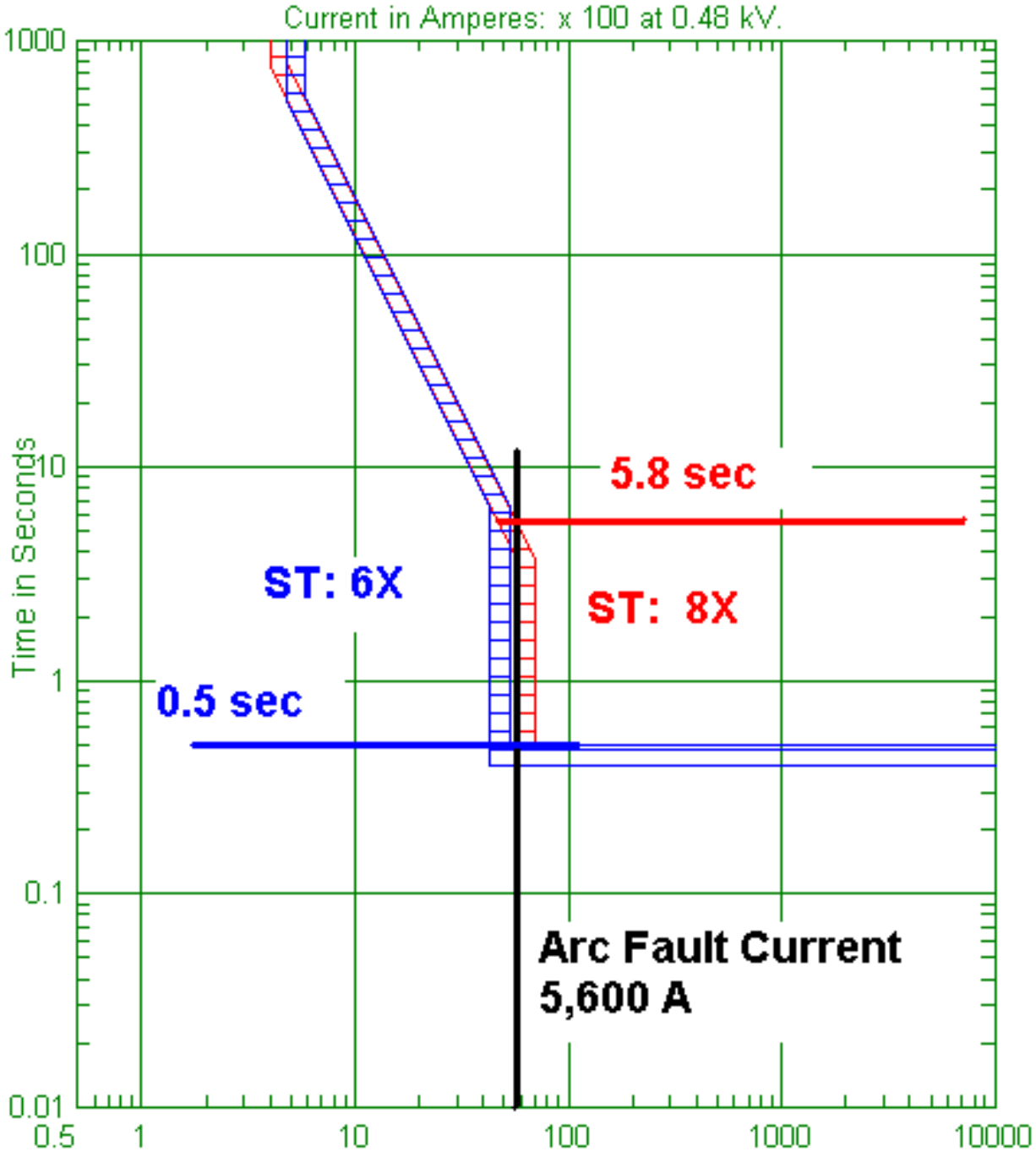
Comparison of Incident Energy

Fuse Type	Time	Energy	PPE
Cur. Limiting	5	302	Too high
Non CL	0.9	54.4	5

Circuit Breaker Setting

- Fault at MCC Bus
- Feeder Breaker Clears Fault
- Compare Arcing Fault Current with Breaker Settings



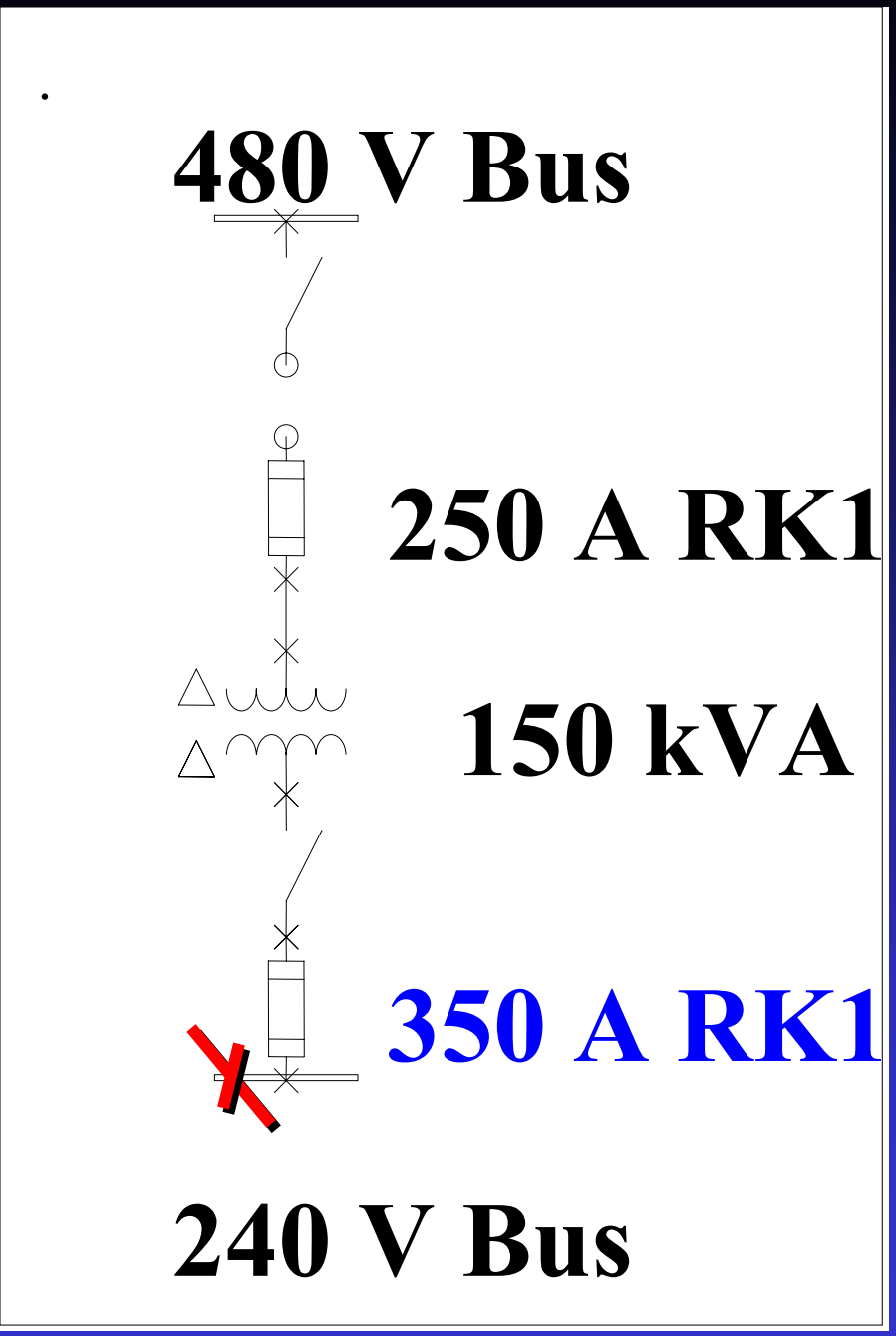

Current in Amperes: x 100 at 0.48 kV.
Time in Seconds
1000
100
10
1
0.1
0.01
0.5
1
10
100
1000
10000
5.8 sec
ST: 6X
ST: 8X
0.5 sec
Arc Fault Current
5,600 A

Circuit Breaker Setting

Comparison of Incident Energy

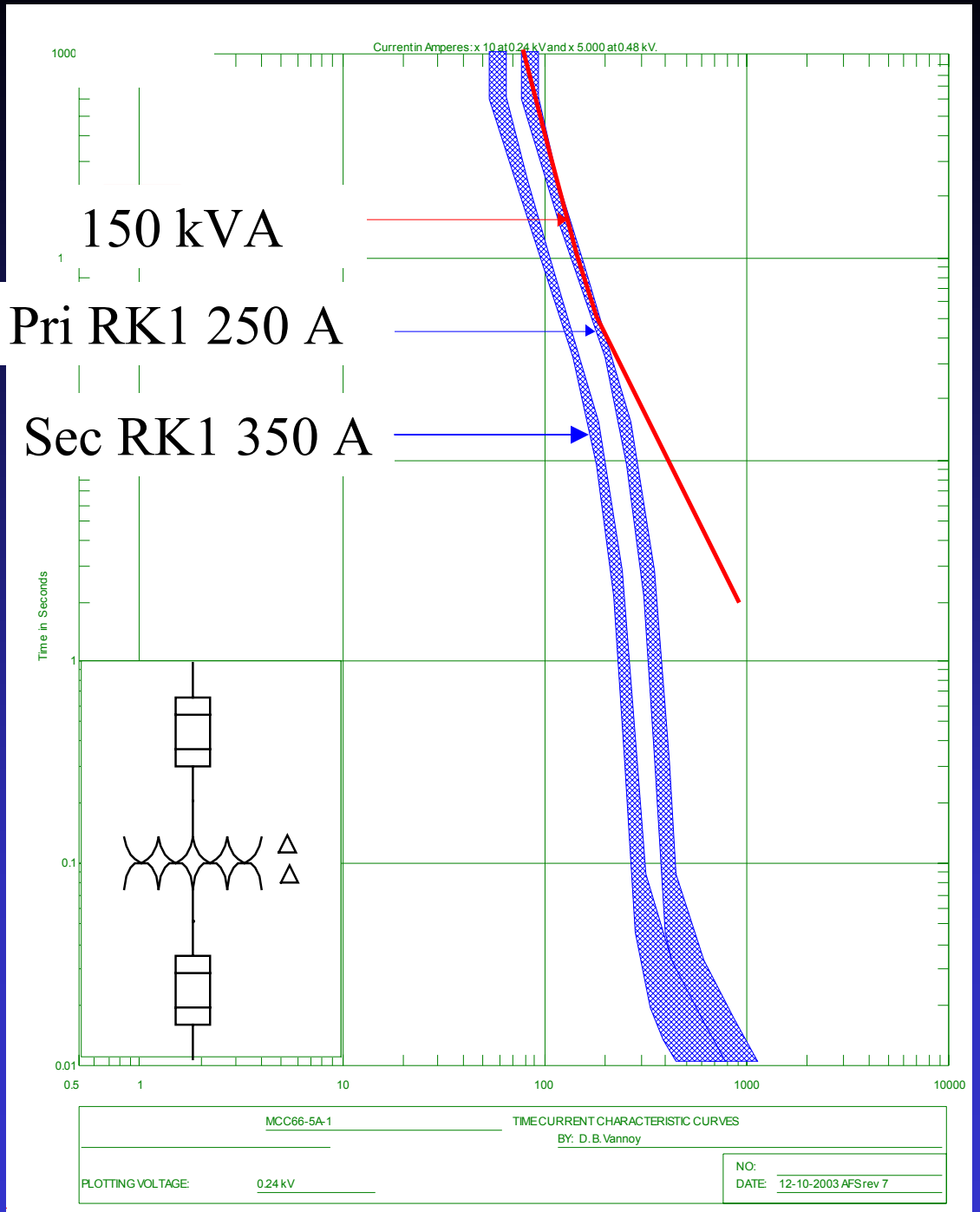
CB setting	Time	Energy	PPE
ST: 8X	5.8	45.6	5
ST: 6X	0.5	3.9	1

Isolation transformer



Isolation transformer feeds heating controls

Added secondary main switch with 350 A RK1 fuse


Current in Amperes: x 10 at 0.24 kV and x 5.000 at 0.48 kV.
150 kVA
Pri RK1 250 A
Sec RK1 350 A
Time in Seconds
1000
1
0.1
0.01
0.5
1
10
100
1000
10000
MCC66-5A-1
TIME CURRENT CHARACTERISTIC CURVES
BY: D. B. Vannoy
PLOTTING VOLTAGE:
0.24 kV
NO:
DATE:
12-10-2003 AFS rev 7

Isolation Transformer
Add Secondary Fuse

Comparison of Incident Energy

Sec Fuse	Energy	PPE
Before:	182	Too high
After:	34	4

Local panels and disconnects

Maximum 480 Volt cable length in feet for incident energy not over 1.2 cal/cm^2 nominal						
Feeder ratings in Amperes	Protective Device	Wire Size	Length 1MVA xfmr	Length 2MVA xfmr	Length 3MVA xfmr	Fuse rating for arc flash model
800	800A L, DSL 206	(2) 500	None	144	257	800 A L
600	600A RK1	(2) 350	297	570	654	600A RK1
400	400A RK1	500	940	1075	1118	400 A RK1
230	250A RK1	4/0	608	677	700	400 A RK1
175	175A RK1	2/0	787	825	837	200 A RK1
150	150A RK1	1/0	664	691	700	200 A RK1
115	125A RK1	#2	425	442	447	200 A RK1
85	90A RK1	#4	772	780	783	100 A RK1
65	70A RK1	#6	476	481	482	100 A RK1
50	50A RK1	#8	302	304	305	100 A RK1
30	30A RK1	#10	205	209	210	100 A RK1
20	20A RK1	#12	131	132	133	100 A RK1

Local panels and disconnects

- Will be under 1.2 cal/cm^2 if:
  - Transformer is rated 1000 kVA or higher
  - Cable length: transformer to MCC to unit is under 700’
  - Protected by 400A RK1 or lower rated fuse upstream
  - Protective devices not overrated to allow motor starting
  - No motor contribution

Other Options

- Racking/Switching Methods
  - Remote Racking
  - Remote Switching
  - Switching Sequence
- New Equipment Design
  - Zone Interlocking - LV, Differential relays - MV
  - Arc Resistant Switchgear
  - “Crowbar” Arc Limiter

Agenda

- Why do a study?
  - A chemical company's experience
  - A refining company's experience
- How we did a study
- System upgrades to reduce exposure
- IEEE 1584
  - P1584 Working Group activities

P1584 Working Group

- First edition
  - In use by many users
- Second edition
  - Planning further testing on more variables
  - Ferraz Shawmut is developing a physics-based model
  - Eaton Electrical / C-H has offered to test
  - Rockwell / A-B has offered to test
  - Powell has agreed to make boxes
  - Test specification in development
  - Other support is welcome!

Summary

- Some companies are committed to doing arc flash hazard studies at all plants.
- The process requires a lot of work, but it is doable.
- The arc flash hazard can be reduced significantly in existing facilities.
- Transformer secondaries are the biggest concern.
- IEEE 1584 first edition can guide the user to identify high hazard equipment.
- IEEE 1584 is being revised.

DOE
2004 Electrical Safety Meeting

Part 1: Arc Hazards Involving High Noise Levels and Shrapnel

Part 2: Arc Flash Product Improvements and Setting Up a Successful PPE Program

July 28, 2004 Las Vegas, NV

Thomas E. Neal, PhD

Sponsored by The Oberon Company

IEEE

What Is An Electric Arc?

- The Passage of Substantial Electric Current Through Ionized Gases
- Typically Lasts Less Than 1 Second
- Extremely High Radiant Energy Component
- Explosive In Nature
- Can Ignite and/or Melt Conventional Work Clothing

Electric Arc Flash Event

High Speed Video

EXPOSURE ENERGY BASICS

Exposure Energy is Expressed in cal/cm^2

Copper Calorimeters or Other Types of Thermal Sensors Are Used to Measure Exposure Energy in FR Fabric and Clothing Test Methods

1 cal/cm^2 Equals the Exposure on the tip of a finger by a Cigarette Lighter in One Second

An Exposure Energy of One to Two cal/cm^2 Will Cause a 2nd Degree Burn on Human Skin

IEEE

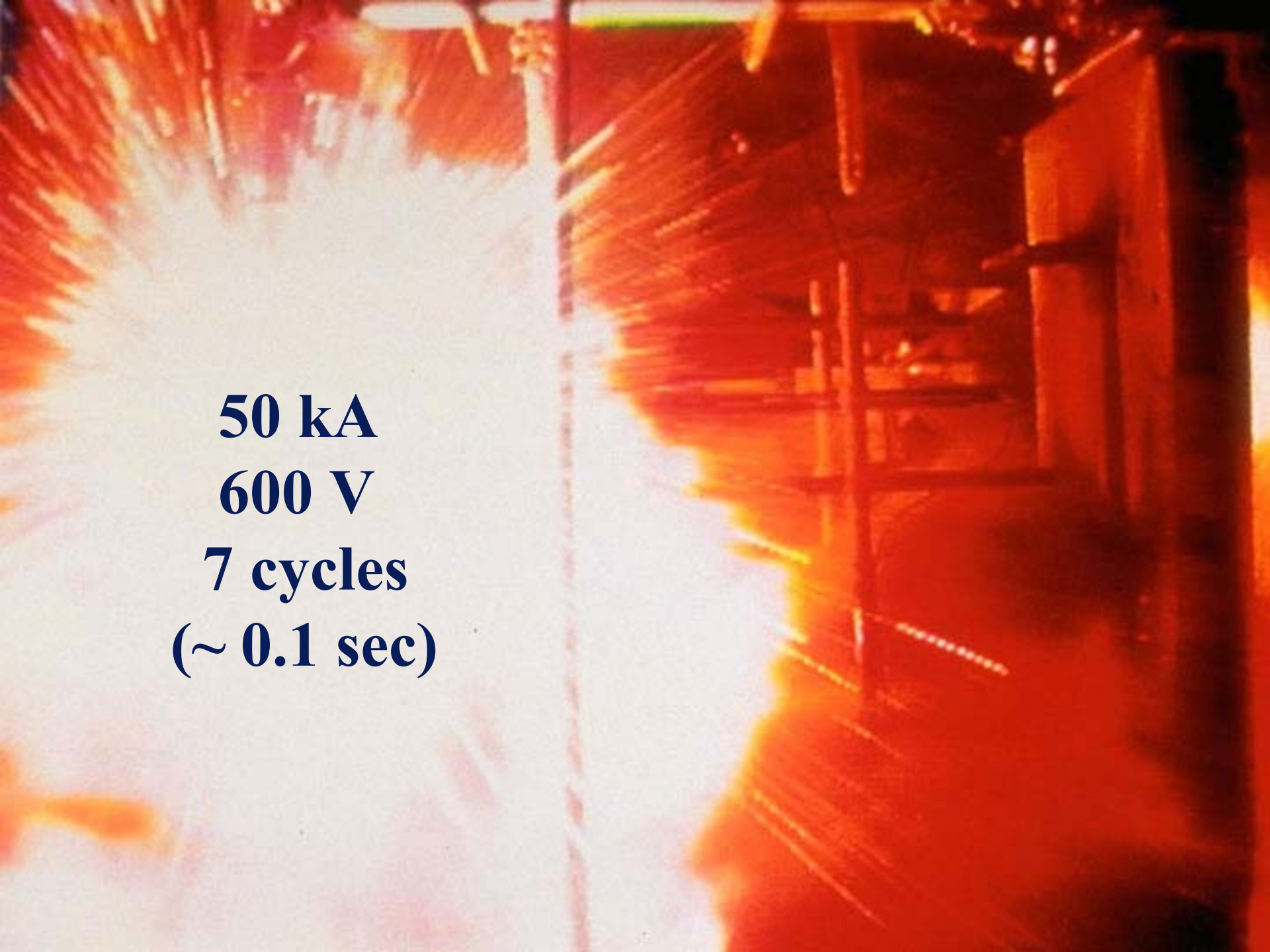
EXPOSURE ENERGY BASICS

- Heat Flux Is the "Flow Rate" of Energy Onto a Surface
- Exposure Energy = Heat Flux X Exposure Time
- Typical Values

	Flash Fire	Electric Arc
Heat Flux cal/cm^{2}sec	1 to 3	1 to 200
Exposure Time seconds	1 to 5	0.1 to 1
Exposure Energy cal/cm^2	2 to 12	2 to 60

- *ARC EXPOSURES IN A FRACTION OF A SECOND CAN BE MUCH MORE SEVERE THAN TYPICAL FLASH FIRE EXPOSURES*

IEEE

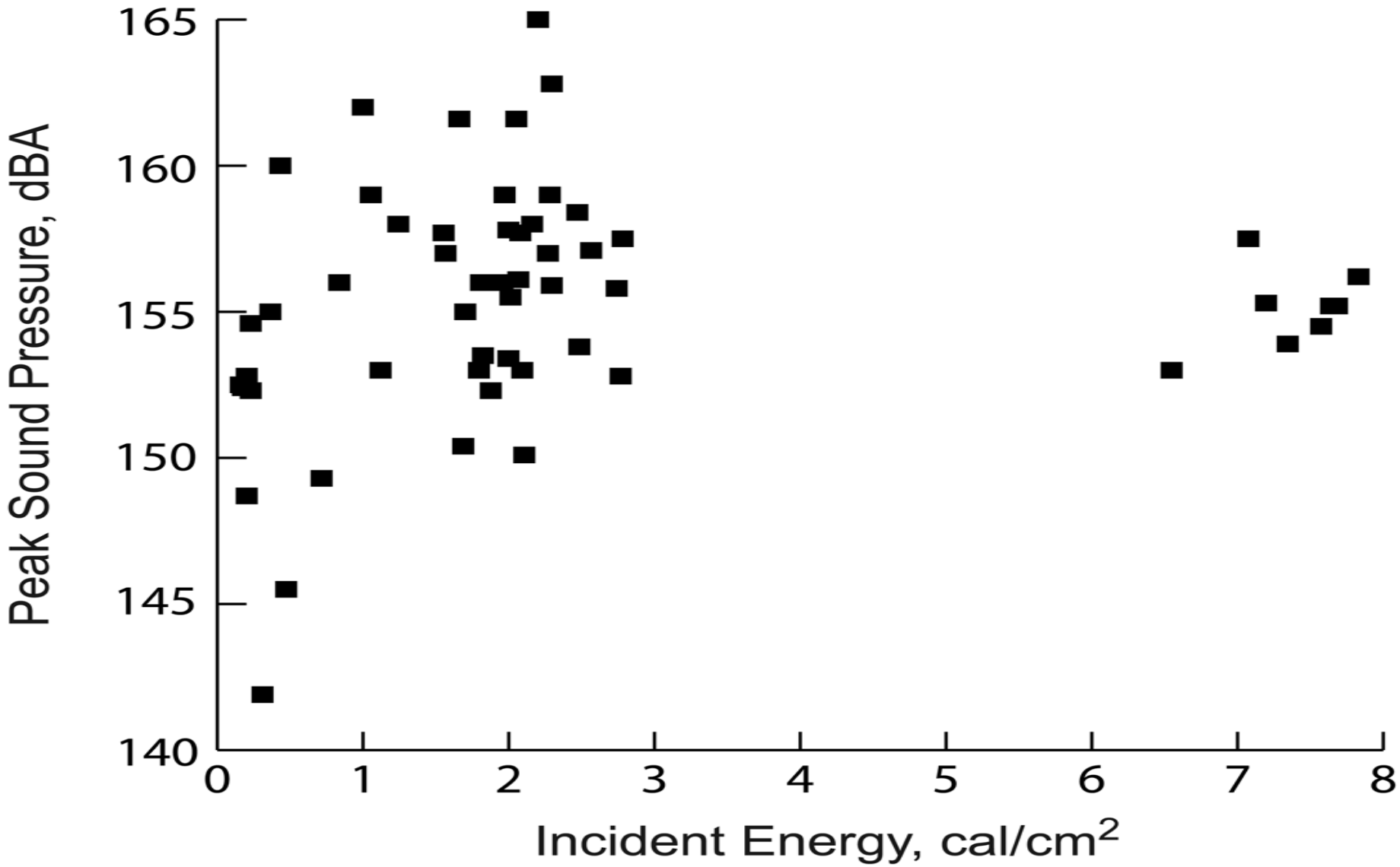

50 kA
600 V
7 cycles
(~ 0.1 sec)

Arc Flash Multiple Hazards

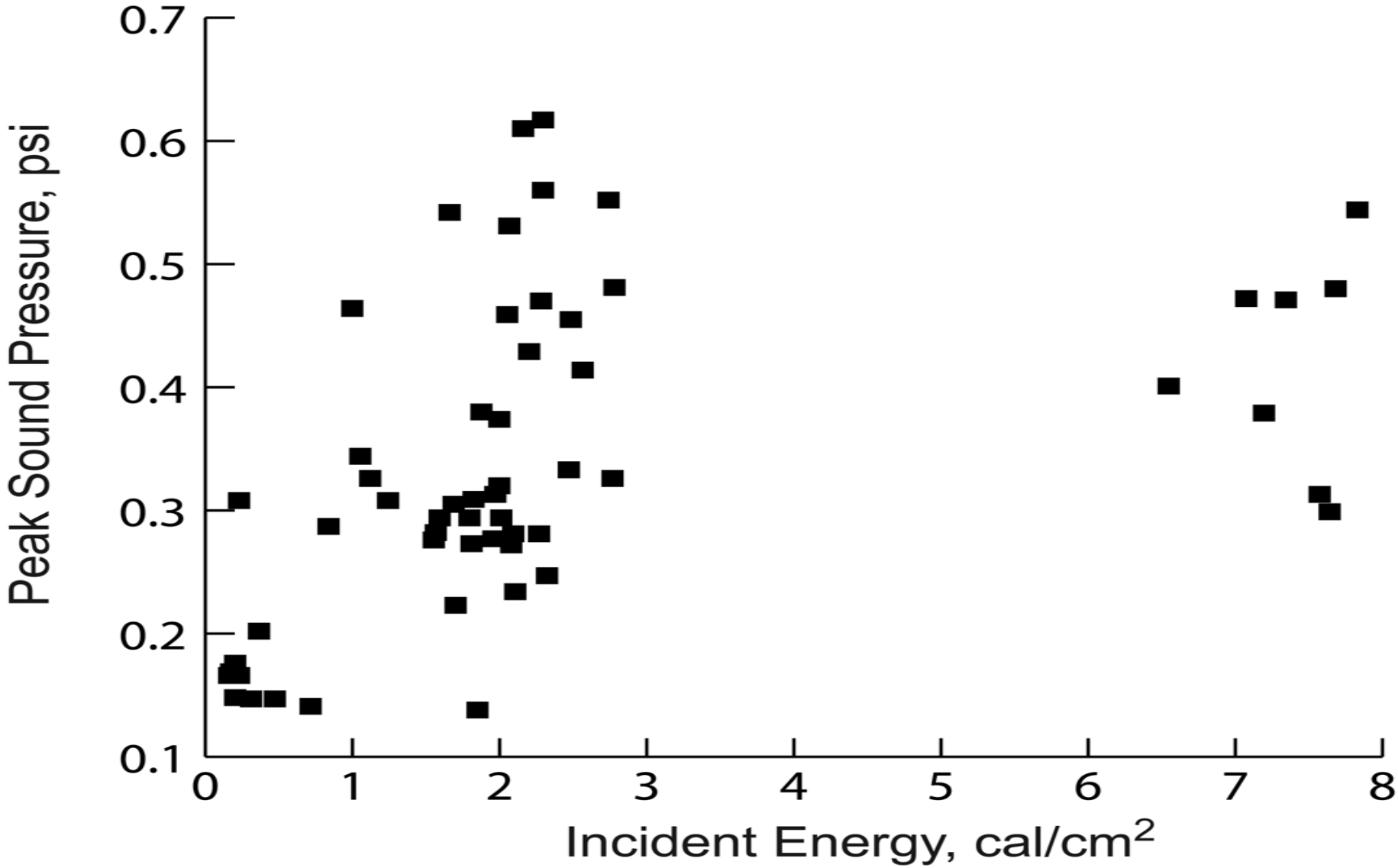
- **Heat Energy Exposure Hazards**
  - **Radiant, Convective, Molten Metal**
  - **Hazard Analysis Established**
- **Arc "Blast" Hazards**
  - **Noise Level & Sound Pressure, Pressure Wave, Shrapnel**
  - **Hazard Analysis Less Established**
  - **Will Require a Different Hazard Analysis Approach than Used for Heat Hazards**

IEEE

Peak Sound Pressure, dBA versus Incident Heat Energy



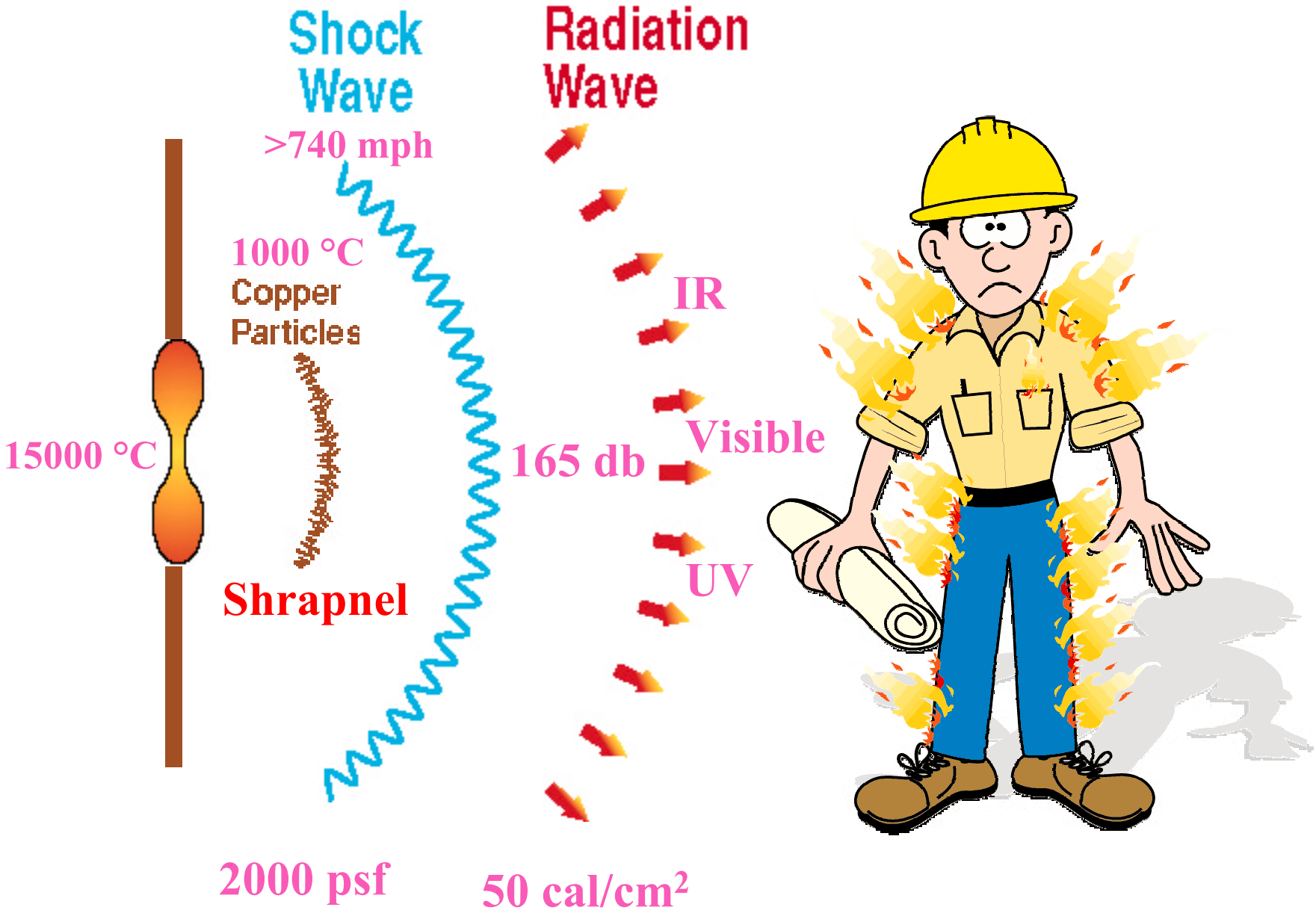
Peak Sound Pressure, psi versus Incident Heat Energy



Arc Blast vs. Heat Energy

- **Arc "Blast" Hazards—Noise Level & Sound Pressure, Pressure Wave, Shrapnel**
  - **Maximum Exposure is Created from Initial Expansion of Gases During the Arc Flash Initiation**
  - **After the First Half Cycle, Arc Duration has Less Impact Since Heated Gases Remain in the Vicinity of the Arc Flash**
- **Heat Energy Hazards—Radiant, Convective, Molten Metal Exposure**
  - **Exposure is Created from the Creation of Plasma and Hot Gases**
  - **Heat Energy Exposure is also Proportional to the Arc Duration**

IEEE


Shock Wave
>740 mph
Radiation Wave
1000 °C
Copper Particles
IR
15000 °C
165 db
Visible
UV
Shrapnel
2000 psf
50 cal/cm²

Arc Blast Hazard Analysis

- Arc "Blast" Hazard Levels—Noise Level & Sound Pressure, Pressure Wave, Shrapnel Will Not Parallel Arc Flash Heat Exposure Level
- Arc "Blast" Hazard Analysis Can Not "Piggy-Back" on the Existing Heat Energy Hazard Analysis Approaches
- New Hazard Analysis Approach Will Be Required to Quantify Arc "Blast" Hazards

Sound Pressure and Noise Hazard

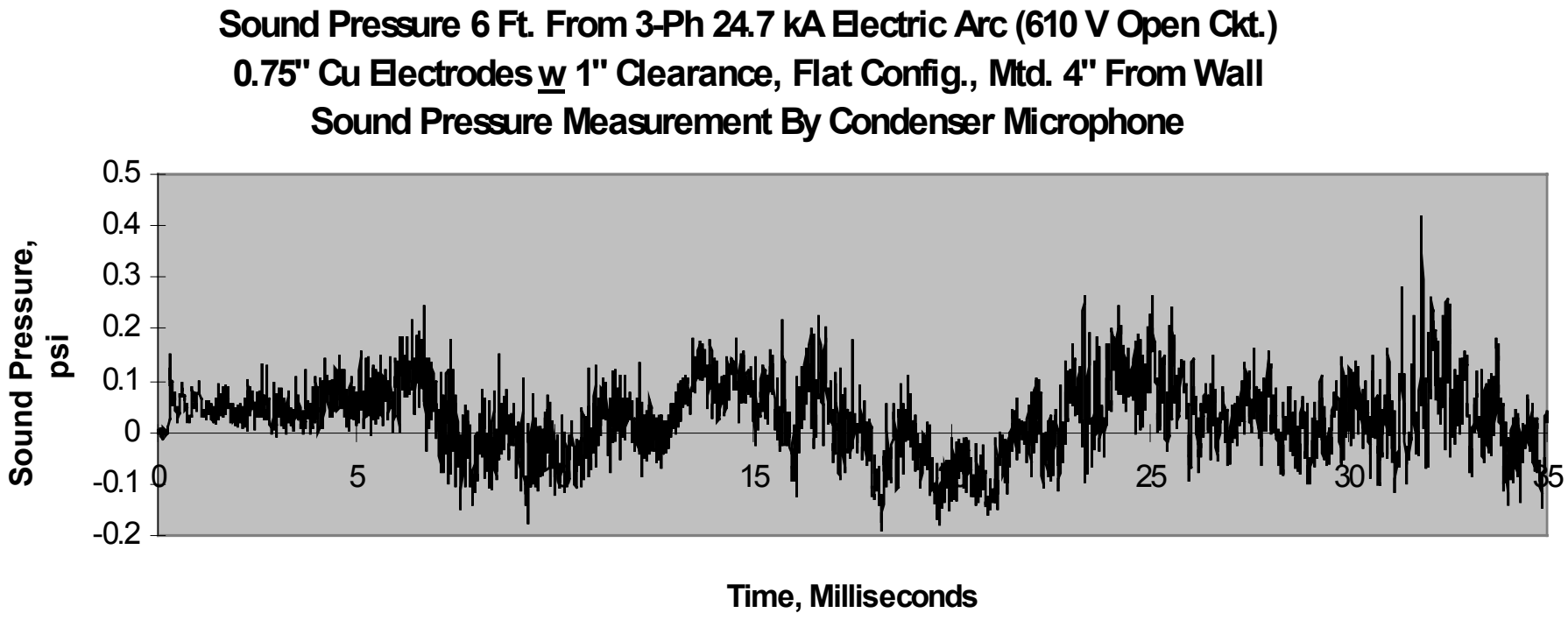
Arc Flash
Sound Pressure Levels Testing

A Single Arc Flash Event Has the Potential to Created Sufficient Noise Levels to Cause Hearing Damage

Richard L. Doughty, Thomas E. Neal, Terrence A. Dear, Allen H. Bingham, "TESTING UPDATE ON PROTECTIVE CLOTHING & EQUIPMENT FOR ELECTRIC ARC EXPOSURE, IEEE, PCIC-97-35, 1997

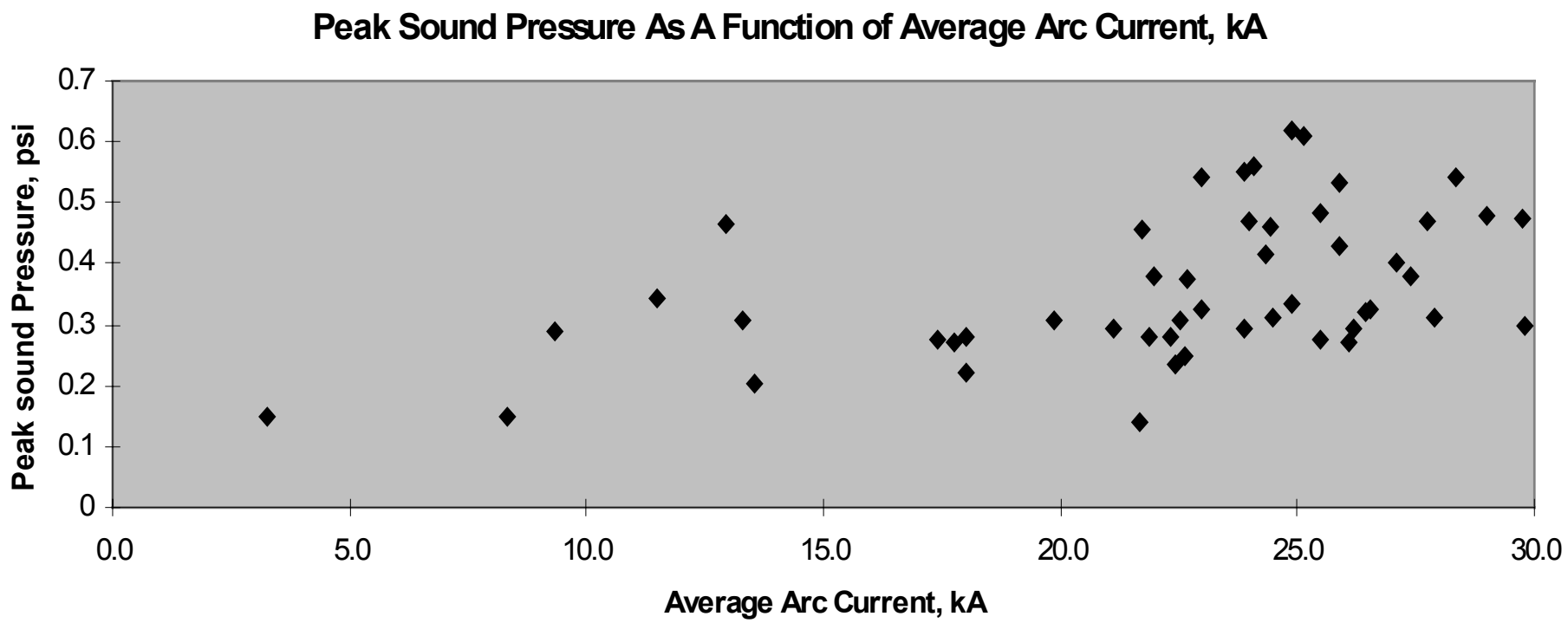
Arc Flash Sound Pressure Tests

- Peak Sound Pressure Occurred at 32 milliseconds
  - ~8 milliseconds for per half cycle (60 cps)
  - ~6 milliseconds for Sound to Travel 6 feet
  - ~18 milliseconds for super-heated gas expansion



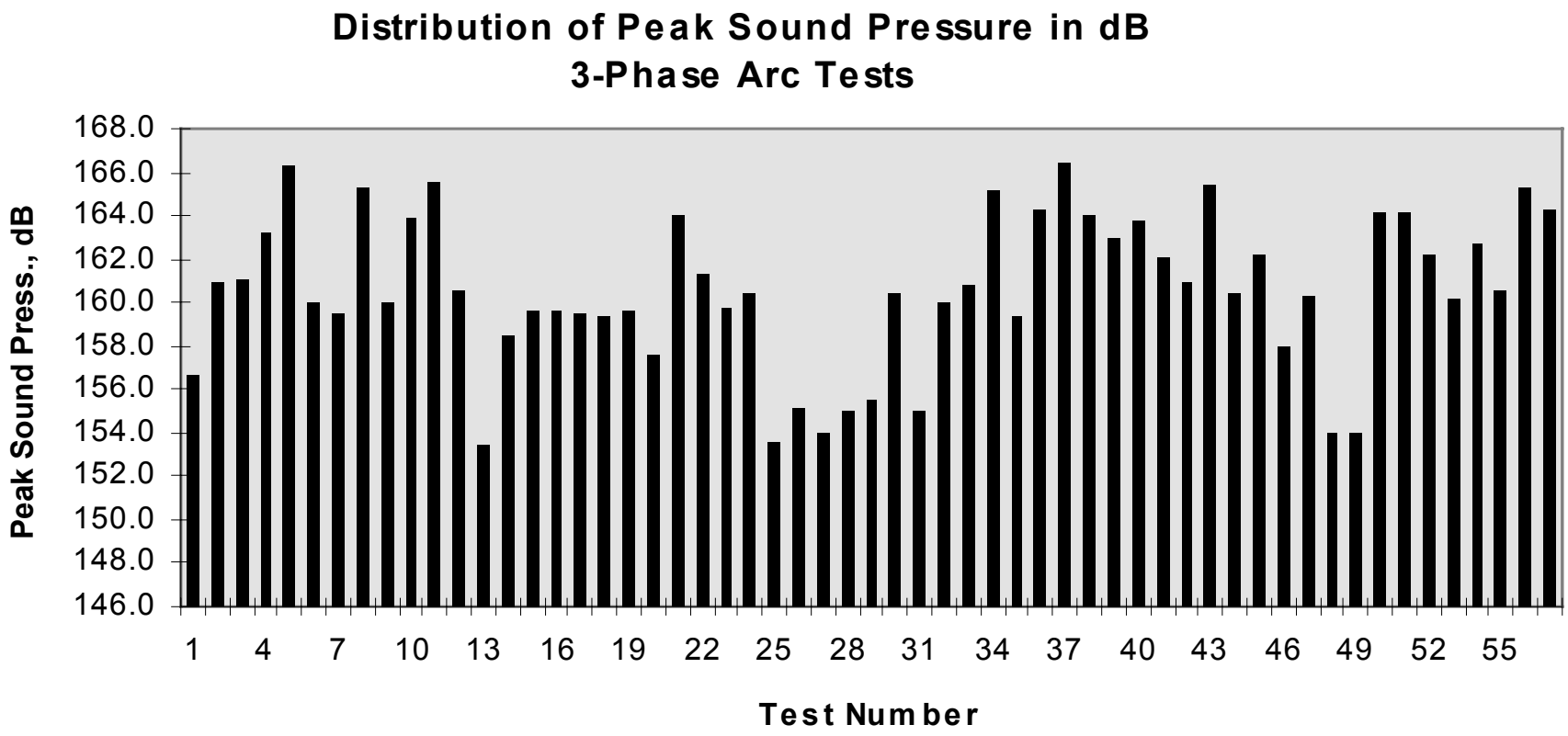
Arc Flash Sound Pressure Tests

- Sound Pressure Increases with Arc Current
- Typical Value of 0.42 psi at 6 feet from Arc Flash
- 0.42 psi = 163 dB
- Sound Pressure Will Increase as Distance Decreases



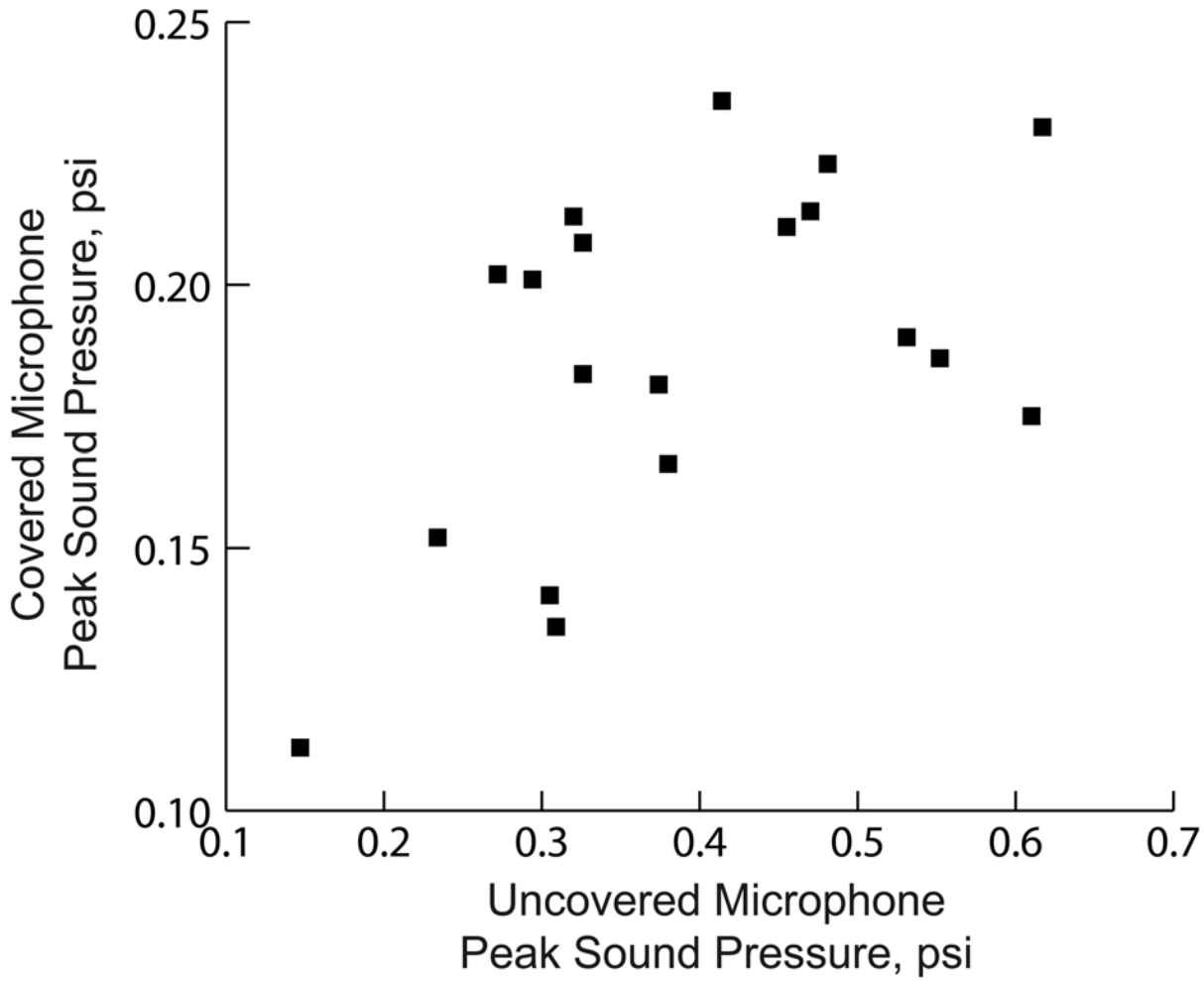
Arc Flash Sound Pressure Tests

- For All Tests Sound Pressure at 6 Feet Exceeds OSHA Levels of 115 dB and 140 dB (dB is a log scale)
- Arc Flash PPE Needs to Include Hearing Protection



Sound Pressure, psi Attenuation Due to Arc Flash PPE Fabric

Sound Pressure is Reduced ~54% For Microphone Covered with a Single Layer of FR Fabric 254 g/m² 60/40 Para-Aramid/ Meta-Aramid Blend Fabric



Noise Reduction Due to Arc Flash PPE Fabric

- Arc Flash Hoods Consisting of Multiple Layers of FR Fabrics and Higher Arc Ratings Can Exhibit >90% Reduction of the Arc Flash Noise Level
- Hearing Protection is Still Required Under an Arc Flash Hood

Pressure Wave Hazard vs. Fault Current

$$\text{Pressure (pounds/ft}^2) = 11.58\,(\text{kA})^{0.9}/D$$

Where: kA = arc flash fault current
D = distance from the arc

- **The pressure on the surface of a worker would be approximately 600 lbs/ft² for a 100 kA arc flash event**
- **An arc-in-a-box would increase the pressure wave intensity exiting from the opening in the enclosure**

Lee, "Pressures Developed by Arcs", IEEE Transactions of Industry Applications, Vol. IA-23, No.4 July/August 1987, page 760-764.

Shrapnel Hazard

Testing of Arc Flash PPE for Shrapnel Hazards

An Arc Flash Shrapnel Hazard:

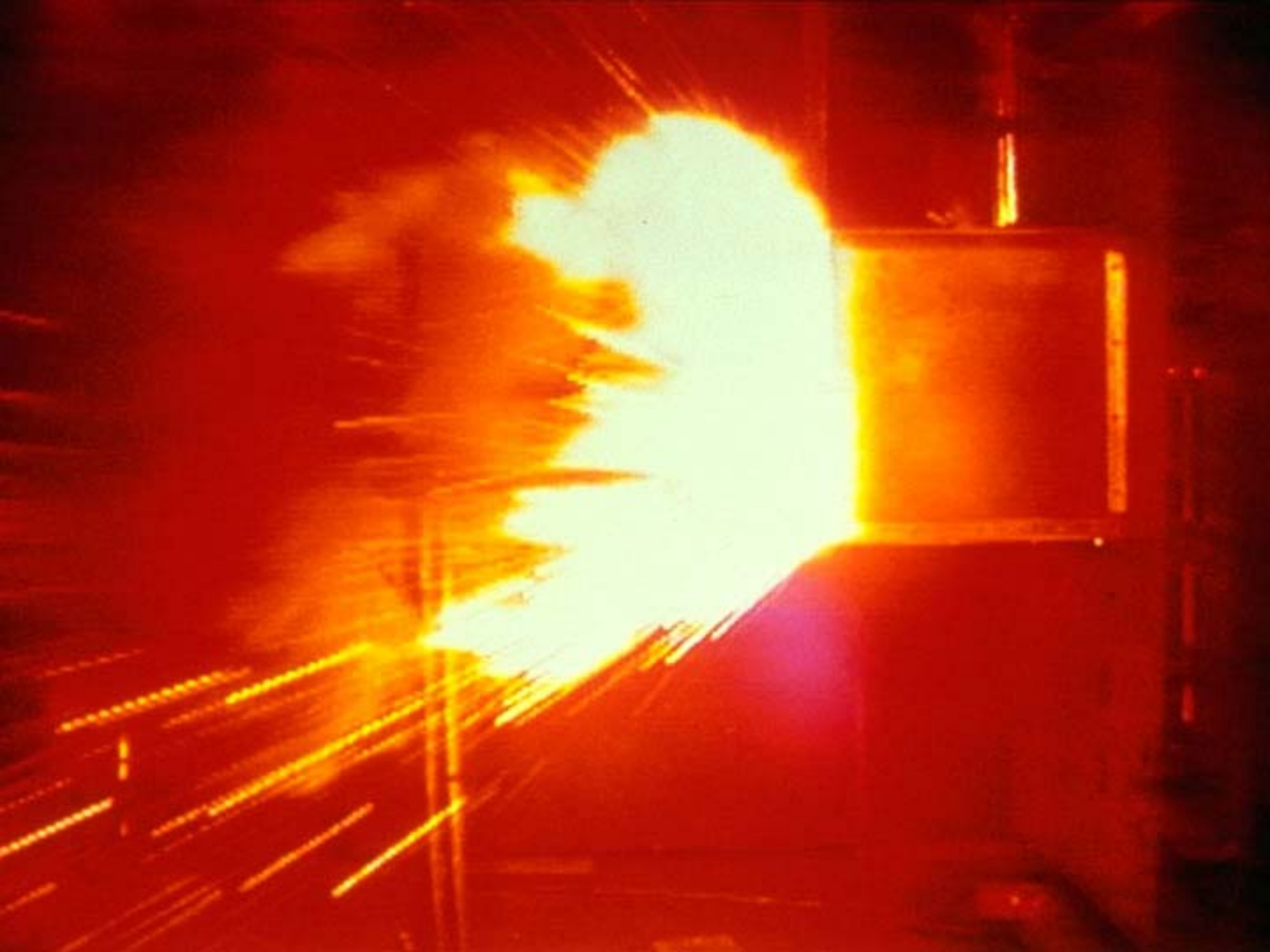
The Generation of Fragments during an Arc Flash Event which are

Moving at Sufficient Velocity to

Cause Injury to a Worker

ARC-IN-A-
BOX
TEST SETUP

42 kA
600 V
7 cycles
(~ 0.1
sec)



ANZI Z87.1 Impact Testing of Arc Flash PPE

- Face Shields and Hood Shield Windows Meet the Impact Requirements of ANSI Z87.1
- ANZI Z87.1 Utilizes a 0.25 inch Steel Ball Projectile traveling at a velocity of 300 fps.
- Many Arc Flash Suits with an Arc Rating at or above 25 cal/cm^2 (H/R Category 3 or greater) Will Also Meet ANZI Z87.1

ANZI Projectile Testing vs. Ballistic Fragment Testing of Arc Flash PPE

- ANZI Z87.1 Utilizes a 0.25 inch Steel Ball Projectile traveling at a velocity of 300 fps.
- Ballistic Fragment Testing Utilizes a O.22 to 0.50 inch Cylindrical Projectile with Sharp Edges traveling at a velocity greater than 500 fps
- Actual Fragment Size, Shape and Velocity of Arc Flash Fragments or Shrapnel is Undefined and are Likely Highly Variable Depending on the Equipment and Available Energy of an Arc Flash Event

Ballistic Testing of Arc Flash PPE

- Initial Testing of Arc Rated Hood Shield Windows Utilizing 0.22 inch Cylindrical Fragments has been Conducted
- V_{50} Results are in the range of 377 to 856 fps for a Range of Hood Shield Windows using 0.22 inch Fragments
- Results are Promising for Providing Arc Flash PPE with Increased Ballistic Protection
- V50 = Velocity at which 50% of Projectiles Penetrate the Target Specimen

IEEE

Ballistic Testing of Arc Flash PPE

- Initial Testing of Arc Flash Suit Fabric Systems Utilizing 0.22 inch Cylindrical Fragments has been Conducted
- V_{50} Results are in the range of 610 to 920 fps for a Range of Arc Flash Suits with Arc Ratings of 80 to over 100 cal/cm^2 using 0.22 inch Fragments
- Results are Promising for Providing Arc Flash Suits with Increased Ballistic Protection
- V50 = Velocity at which 50% of Projectiles Penetrate the Target Specimen

CONCLUSIONS

- Hazard Analysis Conducted for Heat Exposure Will Not Reliably Predict Arc "Blast" Hazard Levels for Pressure Wave, Sound Pressure, Noise Level or Shrapnel Hazards
- A Single Arc "Blast" Event Can Cause a Range of Work Injuries
  - A Pressure Wave Can Exert Sufficient Force on a Human Body to Cause Fall Injuries and Impact Injuries
  - Sound Pressure/Noise Levels are Sufficient to Cause Hearing Damage
  - Shrapnel, i.e. High Velocity Fragments Emitted from An Arc "Blast" Event Can Cause Physical Injury to Workers

CONCLUSIONS (continued)

- PPE Can Reduce the Arc Flash Sound Pressure but Hearing Protection Needs to be Included in Arc Flash PPE for All Heat Exposure Levels
- Shrapnel Hazards for Arc Flash Events Have Not Been Defined, but Enhanced Ballistic Performance for Arc Flash PPE is Can be Determined and Selected as Part of the PPE Selection Process
- Arc Flash PPE is Available with Enhanced Ballistic Performance to Address Arc Flash Shrapnel Hazards

DOE
2004 Electrical Safety Meeting

Part 2

Arc Flash Product Improvements

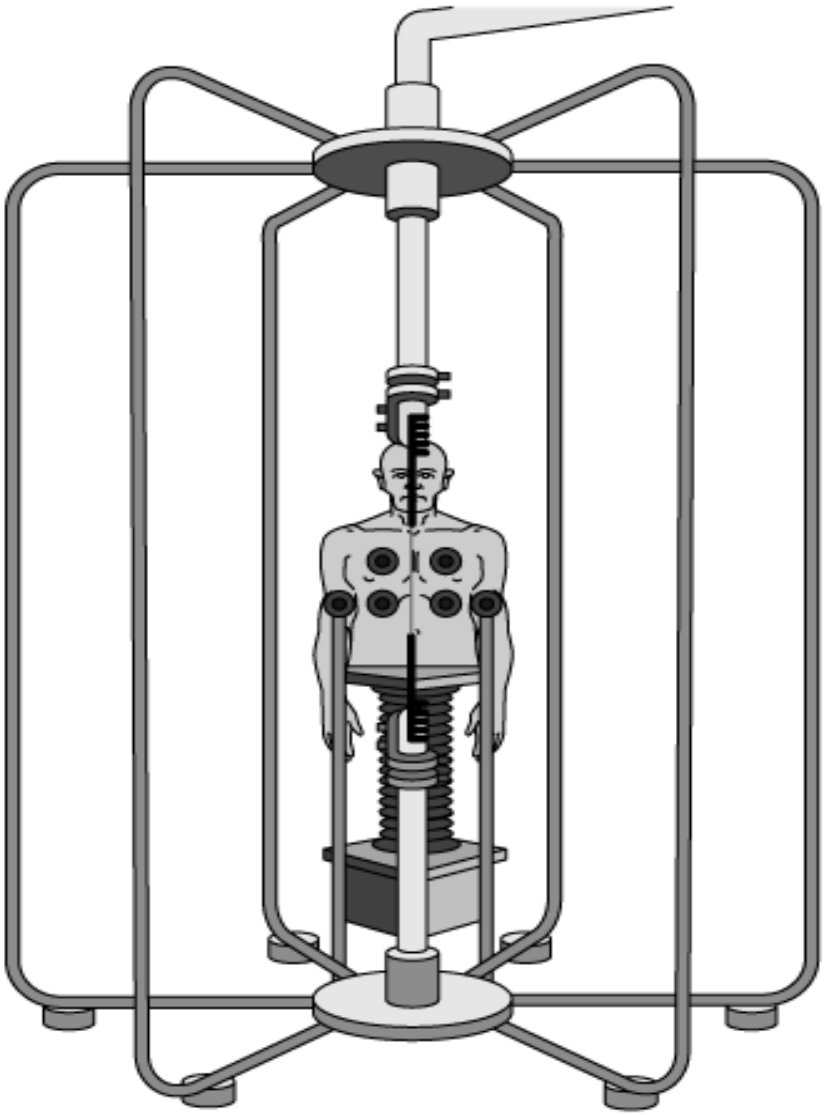
Setting Up a Successful PPE Program

IEEE

Electric Arc Test at the Kinectrics High Current Lab in Toronto

ASTM F 1958 Ignition Test Method

Determines Ignition Energy for Flammable Clothing



Electric Arc Flash Ignition

Before Electric Arc Blast

During Electric Arc Blast

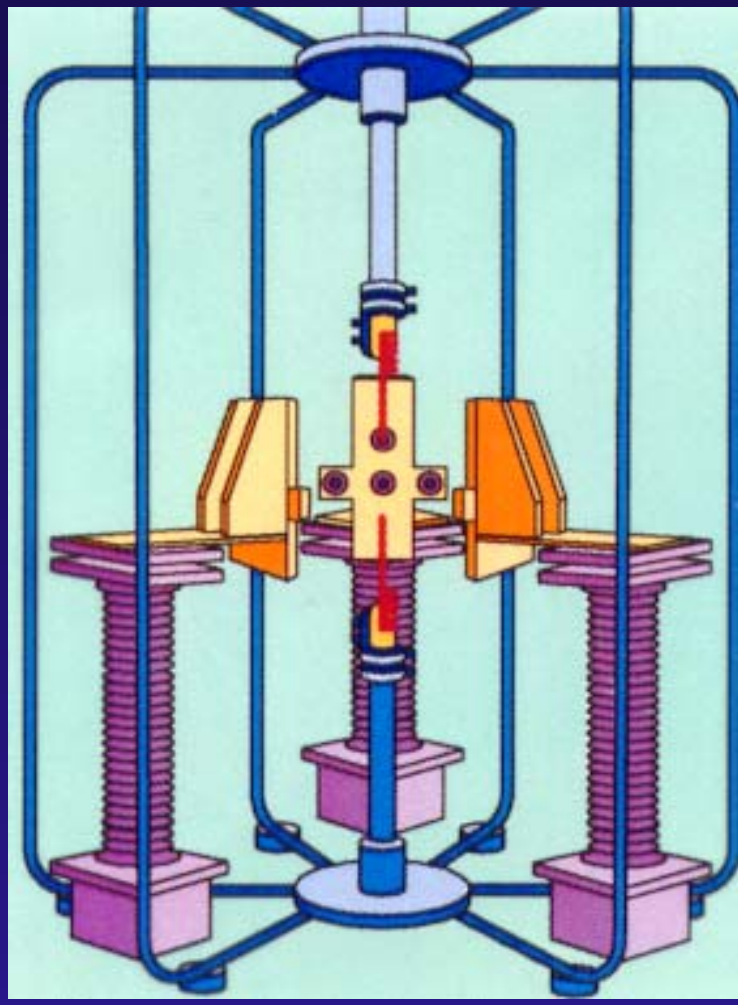
After Electric Arc Blast

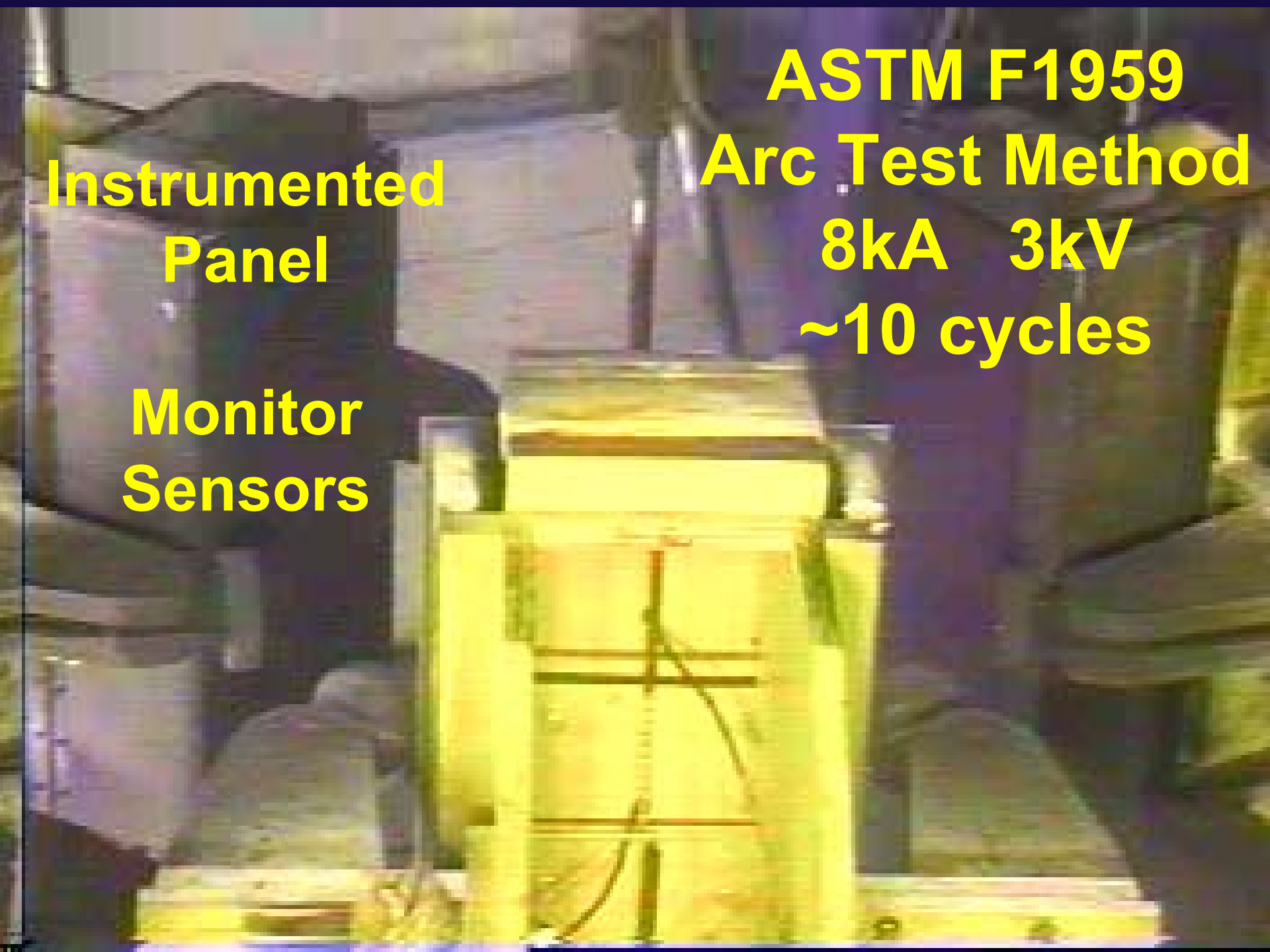
5.7 oz/yd2 Untreated Cotton Shirt

~15 cal/cm²
Exposure
Nomex®IIIA
FR Shirt
Polyester/Cotton
Non-FR Shirt

ASTM F1959 Method for Arc Rating

- Arc Rating of FR Fabrics or Systems
- 20 Fabric Specimens Are Tested On Flat Panels Equipped with Heat Sensors
- Monitor Sensors Measure Incident Energy on the Fabric Surface
- Sensors Under Fabric Measure Energy Transmitted Through Fabric to Simulate Heat Exposure on Worker's Skin
- Uses Fixed Fault Current (8 kA) with Adjustable Arc Duration
- Data Analysis of 20 Test Panel Results Permits Determination of Arc Rating




ASTM F1959
Arc Test Method
8kA 3kV
~10 cycles
Instrumented
Panel
Monitor
Sensors

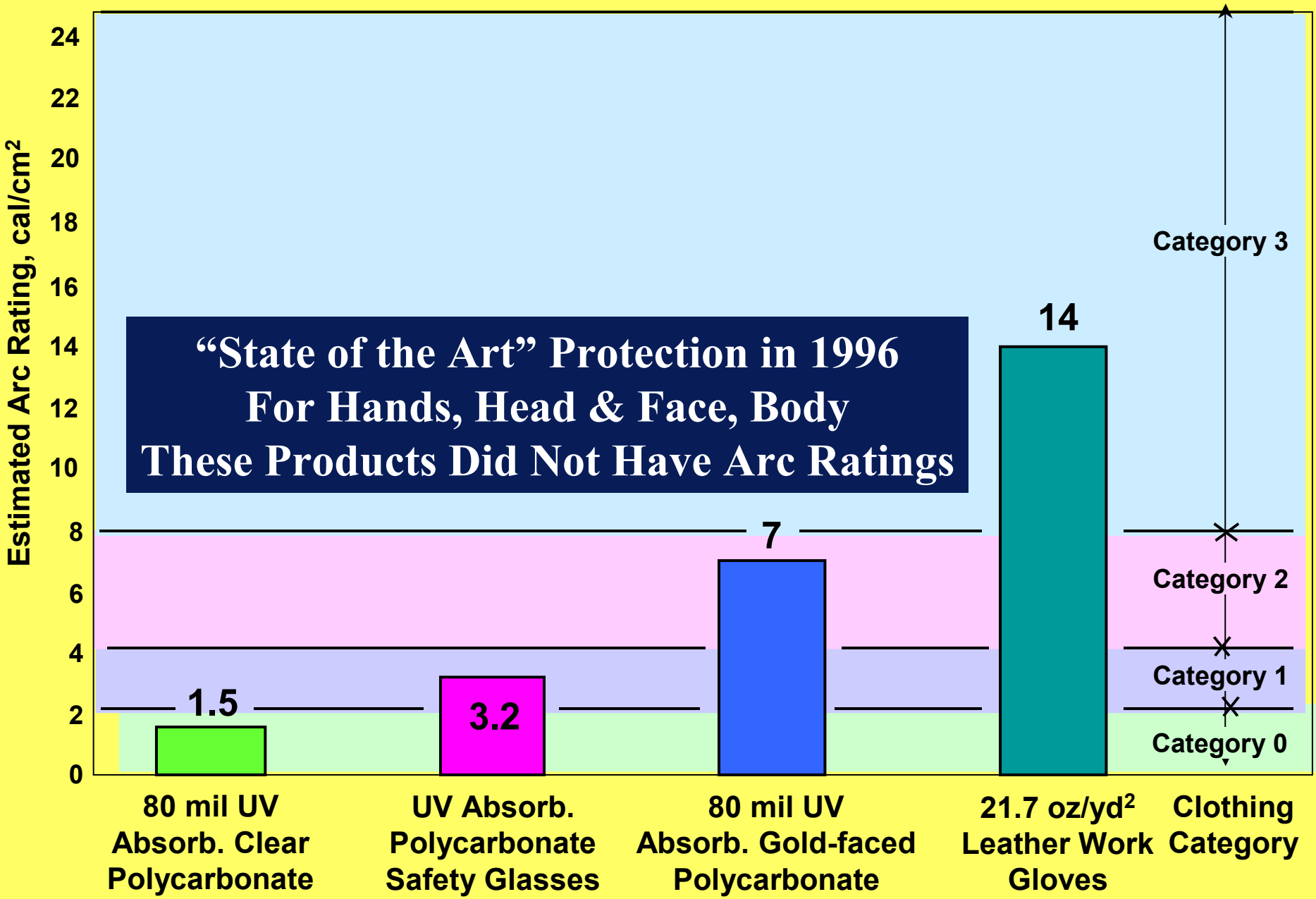
ASTM F2178

Arc Test Method For Determining the Arc Rating of Face Protective Products

Utilizes Eye, Mouth & Chin Sensors

100 cal/cm² Arc Rated Hood

Protective Equipment Comparison



STM F1958 & F2178

Instrumented Mannequin

Clear Face Shield

No Arc Rating

Exposure 66.7 cal/cm²

Hood Arc Rating of 100 cal/cm² is Matched to the Exposure Level

Mannequin B	Mannequin A
98.0 cal/cm²	96.0 cal/cm²

THIRD GENERATION ARC FLASH SHIELD WINDOWS

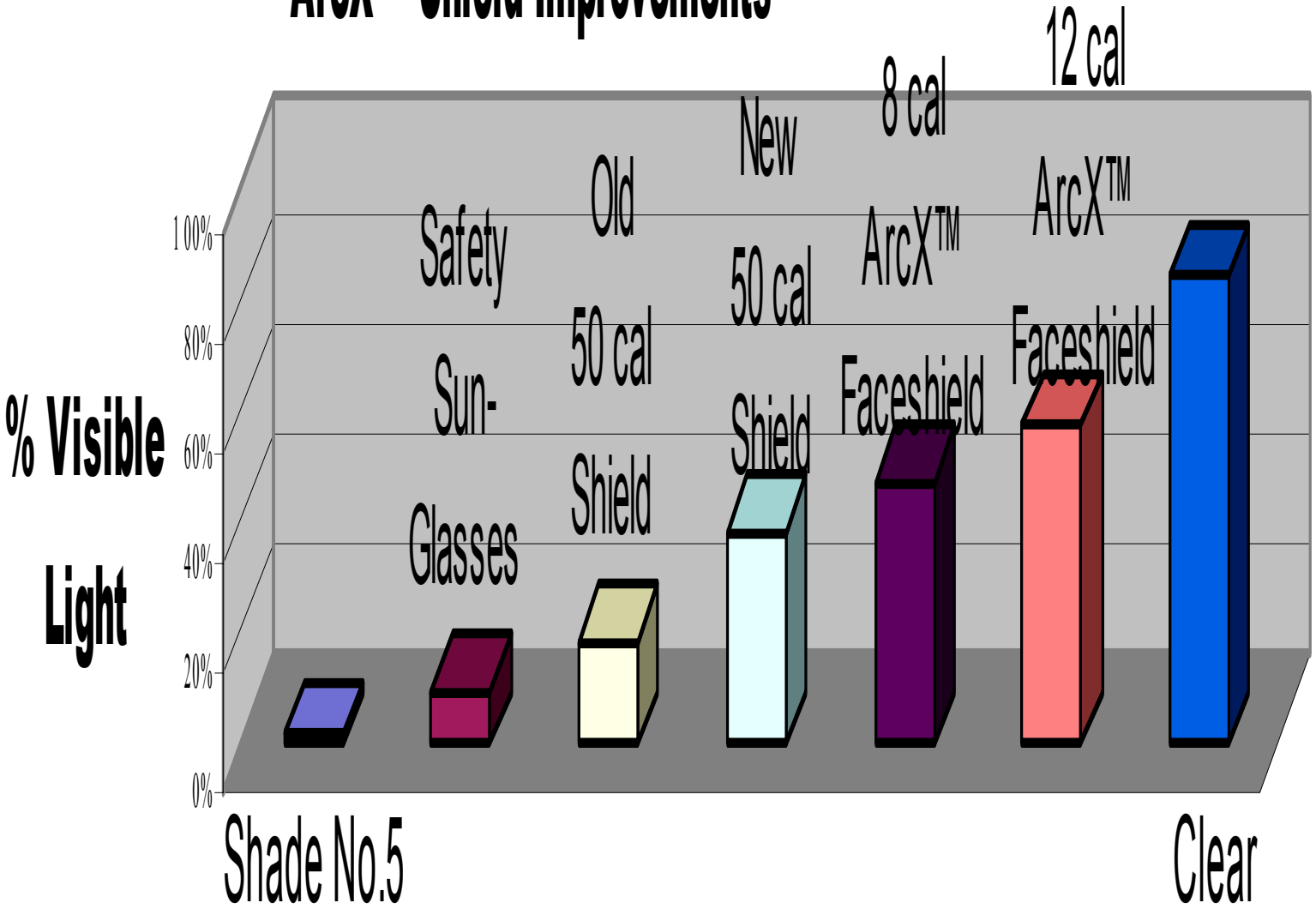
- **Face Protection Became an Issue When it was Observed in 1996 that Clear Polycarbonate Face Shields Blocked Minimal Levels of Arc Flash Energy**
- **At High Exposures Clear Face Shields Melted and Ignited**
- **Products Based on Propionate Polymers Instead of Polycarbonate were Developed in 1997 and 1998 With Arc Ratings Up to 100 cal/cm²**
- *A Third Generation of Face Shield and Hood Shield Window Materials Have Been Developed in 2003 with significantly increases visible light transmission*

3rd Generation Polycarbonate Shield Window

Arc Flash Exposure:

162 cal/cm²

ArcX™ Shield Improvements



Typical Line of Aramid Based Arc Flash PPE

	Arc Rating		% Visible Light Transmission	
Products	Suits	Hood	Previous	New
Face Shield	NA	12	47	58
ARC15	15	18	47	61
ARC25	29	32	New	47
ARC40	43	49	New	48
ARC50	65	65+	19	37
ARC65	70	100	New	37
ARC100	103	120	7	16+
ARC100B*	112	100+	New	16+

*B Indicates Ballistic Reinforcement

Product Improvement—Shield Windows

- The 3rd Generation of Arc Flash Face Shields and Hood Shield Windows is Available with Several Important Improvements
  - Polycarbonate Reliability and Impact Resistance
  - Charring Mechanism for Increased Protection
  - Superior Scratch Resistant Coating on the Outside
  - Anti-Fog Coating on the Inside
  - ***Increased Visible Light Transmission at Every Arc Rating Level, e.g. 2X Visible Light Transmission at the 50 cal/cm² level—Worker Visual Acuity is Significantly Increased***

Product Improvement—Arc Rated Gloves

- In 1996 Heavy Duty Leather Gloves Were Observed to Have an Arc Rating of ~14 cal/cm²
- Rubber Gloves with Leather Protectors were Observed to Offer a Higher Level of Protection
- Recent Test Have Confirmed that a High Level of Protection, but a Glove Test Method is Not Yet Available
- ***In 2003 Oberon Introduced Three Levels of Arc Rated Gloves at 40, 65 and 100 cal/cm² Designed for Tasks which Don't Require a Voltage Rating***

Product Improvement—Lighter Weight

- **New Aramid Layered Systems Can Provide Light Weight Arc Flash Suits with High Levels of Protection**

Typical System Weights for a Range of Arc Ratings

System Rating	1st Generation	2nd Generation
cal/cm²	FR Cotton & Hybrids	Aramid Systems
15 to 20	13 oz/yd²	8.8 oz/yd²
25 to 31	17 oz/yd²	9.7 oz/yd²
40 to 50	24 oz/yd²	12.1 oz/yd²
65 to 76	34 oz/yd²	15.5 oz/yd²
100	41 oz/yd²	24.5 oz/yd²

Two Types of Flame Resistant (FR) Materials Used in Arc Flash PPE

- Inherent/Permanent Flame Resistant Materials are Made of Polymers that Do Not Burn in Air So That No Chemical Are Needed to Provide Flame Resistance
- Flame Retardant Treated Cotton Fabrics are Treated with Chemicals to Provide Flame Resistance

It is Especially Important to Follow the Laundering Instructions for Chemically Treated Cotton Since Bleaching with Chlorine (Clorox®) or Peroxide Bleach Used in Detergents Can Remove the Flame Retardant Chemicals

How to Implement a Successful PPE Program

- Design for Acceptance through Involvement of the Workforce
  - Stress the Concept of Matching Arc Hazard Level with PPE Arc Rating
  - Label Hazards for Exposure Level
  - Make Sure Garments and PPE is Labeled with Arc Rating
  - Provide Education on the Use of Arc Rated PPE
  - Use Resources of PPE Manufacturer to Support Education of Workforce

Utilizing NFPA 70E Layering Options

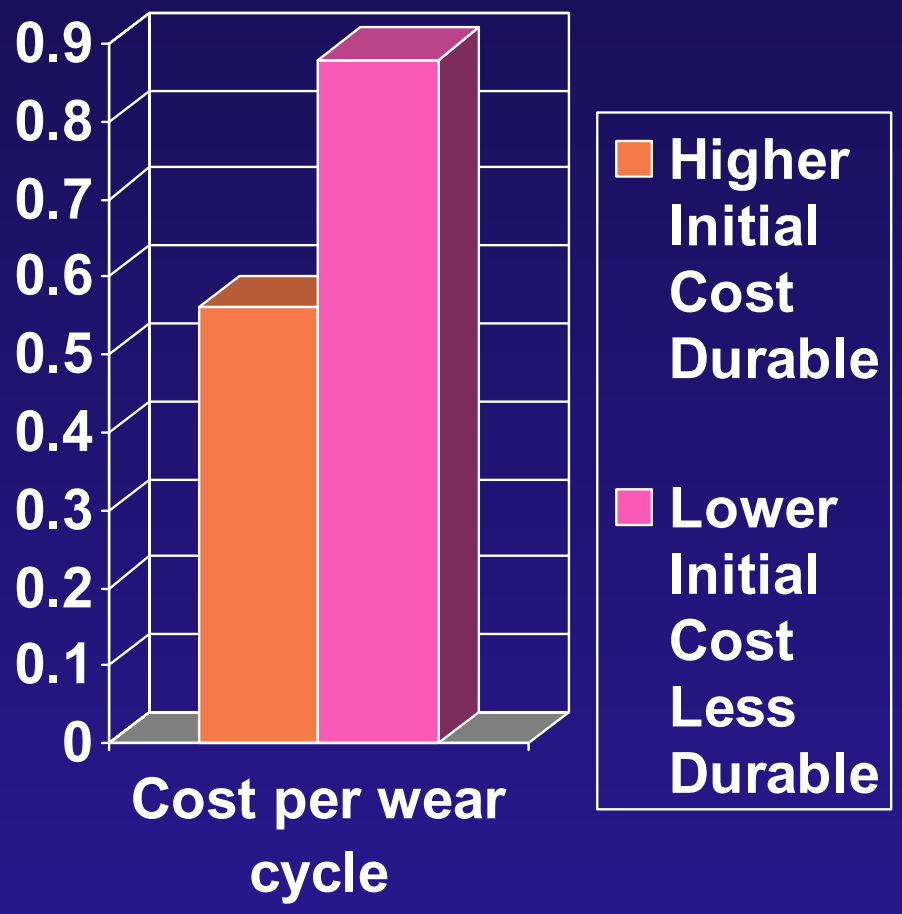
NFPA 70E Hazard/ Risk Category	Required Arc Rating cal/cm^2	Single Garment Approach Arc Flash Suit		Examples—Layering Approach Arc Flash Suit over Everyday FR Clothing NFPA 70E Recommended Protective Systems	
		Body Protection	Face & Head Protection	Body Protection	Face & Head Protection
2 or 2*	8	15 cal Suit 8.8 oz/yd^2	15 cal Hood 8.8 oz/yd^2	Not Available	Not Available
3	25	25 cal Suit 9.7 oz/yd^2	25 cal Hood 9.7 oz/yd^2	15 cal Suit 8.8 oz/yd^2 + FR Coverall or FR Shirt & Pant	25 cal Hood 9.7 oz/yd^2
4	40	40 cal Suit 12.1 oz/yd^2	40 cal Hood 12.1 oz/yd^2	25 cal Suit 9.7 oz/yd^2 + FR Coverall or FR Shirt & Pant	40 cal Hood 12.1 oz/yd^2

FR Clothing & Arc Flash PPE Selection Criteria

- Protection--Arc Rating Labeling
- Wearer Comfort
- Durability
- Cost Effectiveness
  - Initial Cost
  - Life Cycle Cost
- Appearance
- Ease of Care

FR Clothing & PPE Cost Effectiveness

- Initial Purchase Price
- Longevity
- Repair costs
- Life cycle costs



How to Implement a Successful FR Program

- Design for acceptance through involvement of the workforce
  - Education on the Need for PPE and Effective Use of PPE
  - Wear-test a variety of PPE choices
  - Involve the Work Force in the Wear Test and Selection Criteria, e.g. Protection, Comfort, Cost, Durability…

Questions For You To Consider Regarding FR Clothing & PPE

- How Is the Arc Rating Information Provided on the Clothing & PPE Labeling?
- Is the System Arc Rating Available for the Daily Wear FR Clothing When Worn with an Arc Flash Suit
- Who Will Clean and Repair the Garments?
  - Do They Have Necessary Laundry Instructions?
  - Do They Use Appropriate FR Thread and Fabrics for Repair?

Questions For You To Consider Regarding FR Clothing

- Are Your Employees Trained on the Need for FR Clothing and PPE?
- Do They Know When to Wear It?
- Do They Know How to Wear It Properly?

Questions For You To Consider Regarding FR Clothing

- What Is Your Policy Concerning Underwear?
- Do You Prohibit Meltable Synthetics?
- Do You Require That FR Clothing Always Be Worn As the Outermost Layer?

Questions To Ask Your FR Garment & PPE Supplier

- What Is Your Traceability Procedure?
- What Are Your Care & Maintenance Instructions?
- What Industry Standards Do Your Garments & PPE Meet?
- Do You Have Garments Available to Address All of the Arc Flash Hazards My Workers Will Face?
- What Assistance Do You Provide After the Sale?

Questions To Ask Your FR Garment & PPE Provider

- What is the Visible Light Transmission of Your Face Shields and Hood Shield Windows for Each Arc Rating Level?
- What are the Arc Ratings of Your Garments and PPE?
- What Are the System Arc Ratings Including the Layers of Every Day FR Clothing and Arc Flash Suits that My Workers Will be Wearing?
- How Do You Label Your FR Garments and PPE for Arc Rating

In Summary

- Start with Arc Flash Hazard Analysis
- Involve Workers in Hazard Analysis Process
- Determine Appropriate Clothing and PPE Options Based on Matching Arc Rating with Arc Flash Exposure Level
- Educate the Workforce on the Need for FR Clothing and PPE
- Involve Workers in the FR Clothing & PPE Wear Test and Selection Process
- Set Expectations for the FR Program

CONCLUSIONS

- Arc Rated PPE Can be Matched to Arc Hazard Level to Minimize Burn Injury and Preserve Quality of Life
- New Generation Arc Flash Layered Systems can Provide High Levels of Protection at Very Light Weight to Increase Worker Comfort and Freedom of Movement
- New Generation Arc Flash Hood Shield Windows Provide High Levels of Protection with Improved Visible Light Transmission for Improved Worker Visual Acuity
- Involvement of the Workforce is the Key to Launching a Successful FR Clothing and PPE Program
- NFPA 70E Tables Must be Used with Caution Due to Potential for Under-Protection

Questions

Question # 1:

- What does FR (Flame Resistant) mean regarding an “FR” Fabric?

Answer # 1:

- FR in the context of NFPA 70E and ASTM F1506 means that a fabric in a vertical position will self extinguish when the ignition source is removed and will exhibit a limited amount of after-flame and thermal damage (char length) per the ASTM D6413 test method.

Questions

Question # 2:

- What does Arc Rating mean regarding FR Fabrics or systems of FR fabrics?

Answer # 2:

- Arc Rating is the arc incident energy level at which skin under the FR fabric or system of FR fabrics has a 50% of receiving a 2nd degree burn injury. If the fabric breaks open at incident energy lower than this, then Arc Rating is an indication of the point where the FR Fabric begins to exhibit breakopen, i.e. 0.5 in² hole or 1 in long opening.

Questions

Question # 3:

- Is heat stress potential greater for FR apparel than for similar conventional work apparel under similar weather and metabolic rates?

Answer # 3:

FR Apparel, Unless Coated, Is “Breathable”.

- Heat stress is a function of fabric weight, the number of fabric layers and air permeability. FR fabrics are typically no heavier and no less permeable that conventional work clothing fabrics.
- However, with multiple layers required for higher Arc Rating levels, there can be an increased potential for heat stess with H/R Category 3 and 4 clothing systems.

Ray Nellor
Compliance Program Manager

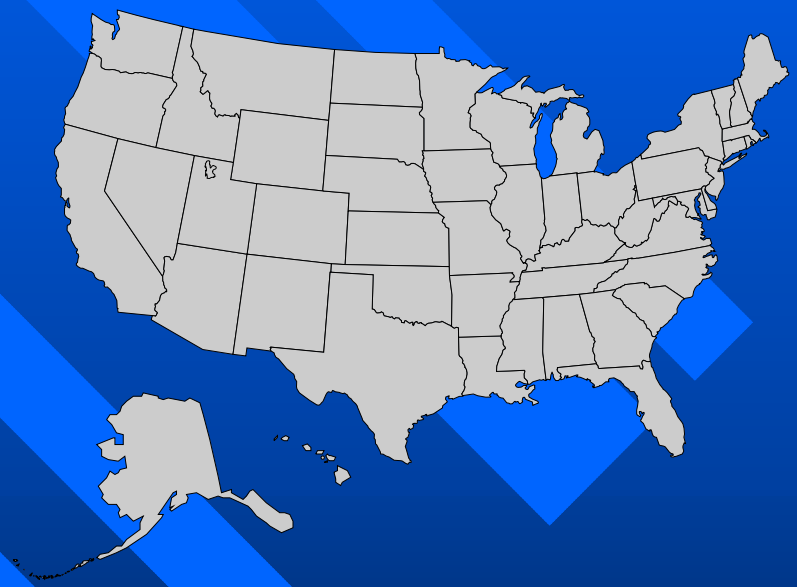
OSHA

Englewood Area Office

303-843-4500

OSHA INSPECTIONS

- Background
  - Need for Legislation
  - OSHA Act of 1970
  - OSHA's Purpose
  - The Act's Coverage



Need for Legislation

- In 1970, Congress considered these annual figures:
- Job-related accidents accounted for more than 14,000 worker deaths
- Nearly 2-1/2 million workers were disabled
- Estimated new cases of occupational diseases totaled 300,000

OSH Act of 1970

- PURPOSE:
- " . . . to assure so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources."

OSHA's Purpose

- Encourage employers and employees to reduce workplace hazards and implement new or improve existing S&H programs
- Provide for research in occupational S&H
- Maintain a reporting and record keeping system to monitor job-related injuries and illnesses

OSHA's Purpose

- Establish occupational S&H training programs
- Develop and enforce mandatory job S&H standards
- Provide for development and approval of state occupational S&H programs

The Act's Coverage

- Extends to all employers and their employees in the 50 states, District of Columbia, Puerto Rico, and all other territories under Federal Government jurisdiction
- Coverage provided either directly by federal OSHA or through an OSHA-approved state program

The Act's Coverage

- Employer defined as any "person engaged in a business affecting commerce who has employees, but does not include the United States (except for the U.S. Postal Service) or any State or political subdivision of a State"

Where to Get Standards

- Federal Register in public libraries
- CD-ROM subscription through U.S. Government Printing Office (GPO)
- Internet access through OSHA Home Page - OSHA standards, interpretations, directives. (http://www.osha.gov)

OSHA INSPECTIONS

- Inspection Priorities
  - Imminent Danger
  - Catastrophes and Fatal Accidents
  - Complaints and Referrals
  - Follow-up Inspections

OSHA INSPECTIONS

- Preparing for the Inspection
  - Inspector's Credentials
  - Opening Conference

Compliance Officer's Credentials

- Compliance Officer displays credentials
- Asks to meet an appropriate employer representative
- Employers should always ask
- Employer can call local OSHA office to verify

Opening Conference

- Officer explains how the establishment was selected
- Officer explains what the likely scope of the inspection will be
- Officer determines if a consultation visit is in progress

Opening Conference

- Officer explains the purpose of the visit
- Officer provides a copy of the complaint (if applicable)
- Officer asks for an employer representative to accompany them during the inspection

Opening Conference

- Officer asks for an authorized employee representative (union) to accompany them during the inspection

The Inspection Process

- Officer proceeds through the establishment to identify safety and health hazards
- Officer determines route and duration of the inspection
- Officer talks privately with employees

The Inspection Process

- Officer notes safety and health condition and practices
- Officer takes photos/videotapes
- Officer measures noise levels
- Officer collects air samples to monitor employee exposure to toxic fumes, gases, and dust

The Inspection Process

- Officer evaluates existing engineering controls
- Officer examines records and programs
- Inspection may cover part or all of an establishment
- Trade secrets remain confidential

The Inspection Process

- Employees are consulted, in private, about safety and health conditions and practices
- Employees are protected from discrimination for exercising their rights
- Records (deaths, injuries, illnesses, first reports, haz com)

The Inspection Process

- Officer points out unsafe or unhealthful conditions
- Inspector discusses feasible corrective action
- Violations corrected immediately may reflect employers good faith for penalty consideration

The Closing Conference

- Employer provided *"Employer Rights and Responsibilities Following and OSHA Inspection (OSHA 3000)"*
- Officer reviews all observed unsafe and unhealthful conditions
- Officer indicates violations for which a citation and penalty may be issued

The Closing Conference

- Officer will <u>not</u> indicate any specific penalty but informs employer of appeal rights
- Good time for the employer to produce records of compliance efforts and provide information to help determine timeframes for abatement

The Closing Conference

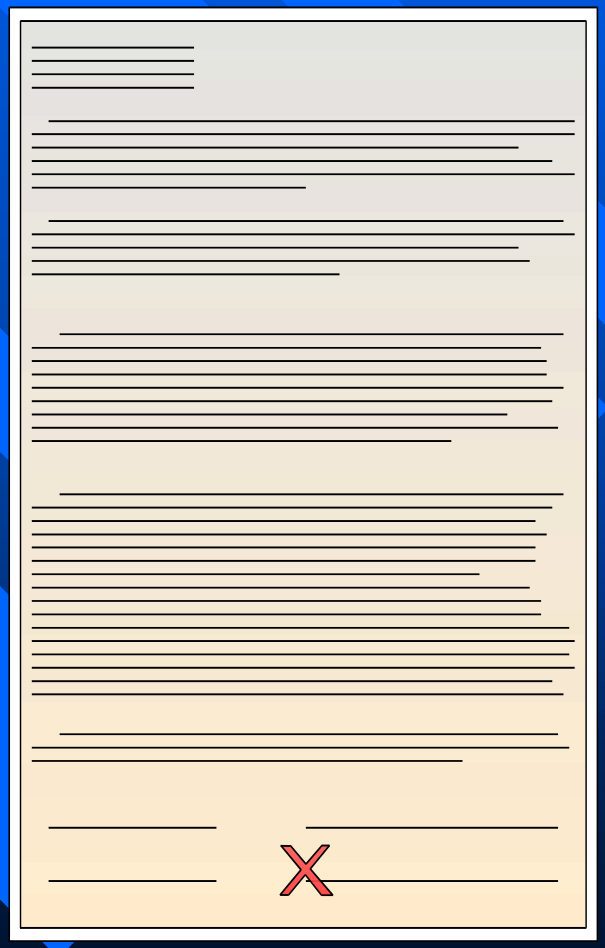
- Officer may determine if second closing conference is necessary (air monitoring)
- Officer discusses OSHA's full service resource program
- Separate closing conference if employee representative does not participate

The Closing Conference

- Officer reports findings
- Area Director determines whether citations will be issued and whether penalties will be proposed

Citations

- Inform the employer and employees of the regulations and standards alleged to have been violated
- Inform the employer and employees of the proposed length of time set for their abatement



Citations

- Employer will receive citations and notices by certified mail
- Employer must post a copy of each citation at or near the place the violation occurred for 3 days or until it is abated

Violations

- Other-than-serious
- Serious
- Willful
- Repeated
- Failure-to-abate

Other-Than-Serious

- Direct relationship to job safety and health but would not cause death or serious physical harm
- Penalty $0 to $7000

Serious

- Substantial probability that death or serious physical harm could result
- Penalty up to $7000

Willful

- Penalty $5000 to $70,000
- Criminal sanctions may be imposed if resulting in the death of an employee
  - Penalty of $250,000 ($500,000 corporation)
  - or 6 months imprisonment
  - or <u>both</u>

Repeat

- Inspection reveals a substantially similar violation is found and the original citation has become final order
- Penalties up to $70,000 for each violation

Failure-to-Abate

- Employer fails to correct a prior violation
- Penalties up to $7000 per day beyond the prescribed abatement date

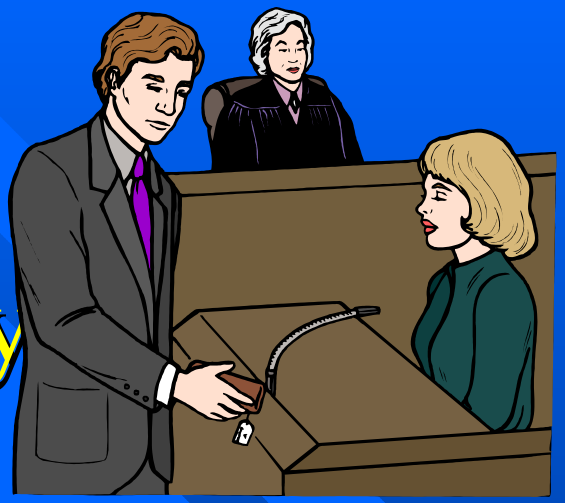
Appeals by Employees

- Employee (or authorized representative) may request an informal review if no citations are issued if a complaint initiated the inspection
- Employees <u>cannot</u> contest citations or penalties
- Employees <u>can</u> contest abatement dates

Appeals by Employees

- Employees can contest an employer's Petition for Modification of Abatement (PMA)
- Must be done within 10 working days of posting
- Employees may request an informal conference with the Area Director to discuss issues of the inspection, citation, penalty, or employer's notice of contest

Appeals by Employ



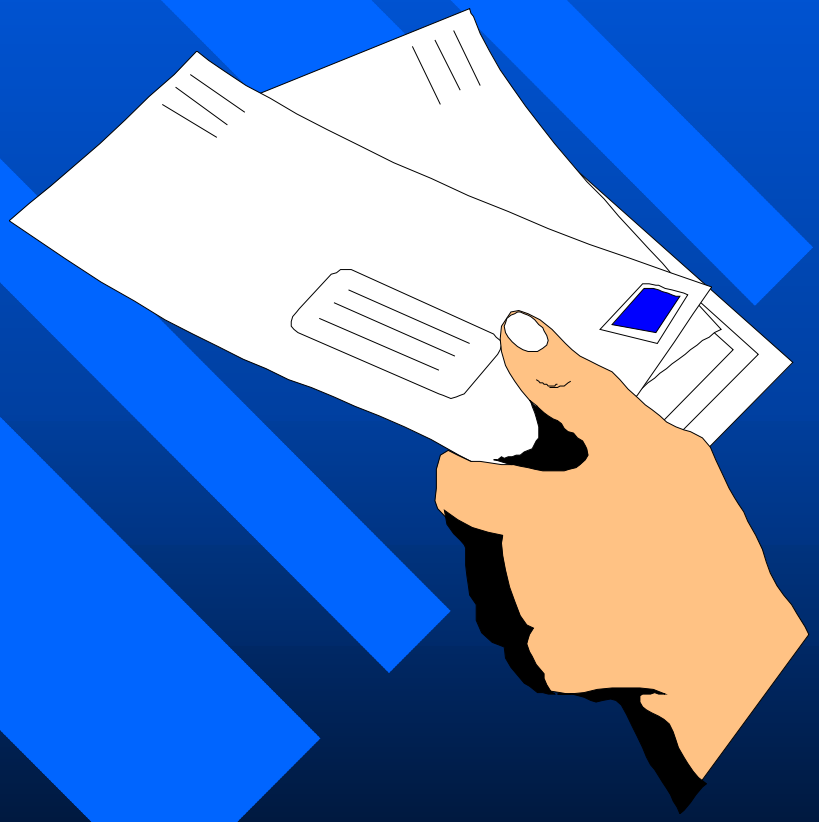
- Employer (who wishes to contest) must submit a written objection to OSHA within 15 working days
- Area Director forwards to the Occupational Safety and Health Review Commission (OSHRC)

Appeals by Employers

- Informal conference with the Team Leader or Area Director
- Area Director is authorized to enter into settlement agreements
- Citations and penalties maybe revised

Notice of Contest

- Employer has 15 working days to contest the citation, penalty, or abatement period
- Must be in writing
- Must clearly identify basis for filing



Notice of Contest

- Will become “final order”, without appeal, if not submitted timely
- Must be posted in a prominent location or given personally to each employee

Questions

- nellor.ray@dol.gov
- 303-843-4500

Considerations in Selecting PPE for the Arc Thermal Hazard

2004 DOE Electrical Safety Meeting

Roger F. Parry, PhD

DUPONT®

AGENDA

BURN INJURY & MATERIAL MEASUREMENT FUNDAMENTALS

SELECTION OF PROTECTIVE CLOTHING & NFPA 70E

THINGS IN THE WORKS
STANDARDS & UPDATES

ELECTRICAL HAZARDS

ELECTRIC SHOCK

Current Flow Through or on the Body

ELECTRIC SHOCK IMPORTANT - NOT THIS PRESENTATION

NON-CONTACT BURN INJURY

Electric Arc Radiant Heat Energy Exposure

PRESENTATION SUBJECT

ELECTRICAL HAZARDS

Threats Inside the Arc Flash Protection Boundary

- Intense Radiant Energy > 1.5 cal/cm^2
  - 2nd & 3rd Degree Burns for Unprotected Skin
  - Minimum Ignition Energy for non-FR Clothing
- Molten Metal Splatter / Hot Gases / Smoke
- Secondary Fire (Transformer Oils ..)
- Battery Acids
- Potential Concussive Forces
- Damaging Sound Pressure Level

BURN INJURY IN THE WORK PLACE

- High Frequency of Arc Flash Burn Injuries in NA*
  - 5 to 10 / Day Requiring Burn Center Treatment
  - Many More Estimated in Unreported Cases
- Many Cases Clothing Ignition Increased Severity

Bottom Line

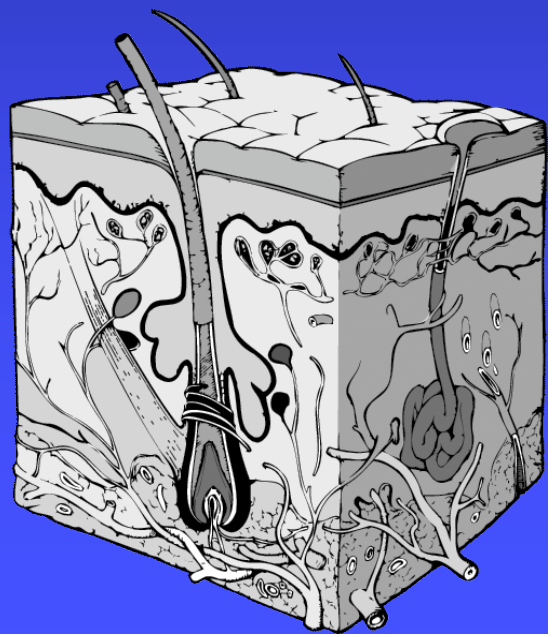
Incorrect Clothing can Increase Severity
The Hazard is Underestimated

* From Statistics Compiled by CapSchell, Inc., a Chicago-based Research and Consulting Firm Specializing in Preventing Workplace Injuries and Deaths.

BURN INJURY PRINCIPLES

Burn Depth is a Measure of Severity

- 1st Degree: Skin Becomes Red, No Blister
- 2nd Degree: Skin Blisters, Epidermis Damaged, ~100µm
- 3rd Degree: Full Thickness Destroyed (Dermis)
  - Skin cannot Regenerate
  - Scar Tissue Forms
  - Injury Depth ~1,000µm
- 4th Degree: Muscle & Bone Destroyed



BURN INJURY PRINCIPLES

Sensation	Skin Color	Tissue Temperature °C	Tissue Temperature °F	Process	Injury
Numbness	White	↑	↑	Protein Coagulation	Irreversible
	Mottled Red & White	72	162	Thermal Inactivation of Tissue Constituents	Possibly Reversible
Maximum Pain	Bright Red	68	154		
Severe Pain	Light Red	64	147		Reversible
Threshold Pain		60	140		
Hot	Flushed	56	133		
Warm		52	126		
Neutral	Flesh	48	118	Normal Metabolism	None
		44	111		
		40	104		
		36	97		
		32	90		
		28	82		

From: A.M.Stoll, "The Role of Skin in Heat Transfer", Advances in Heat Transfer, Vol 4, Academic Press, NY (1967) 115-141

Clothing Ignition

BURN INJURY PRINCIPLES

Arc Exposures Can Easily Exceed Human Tissue Tolerance

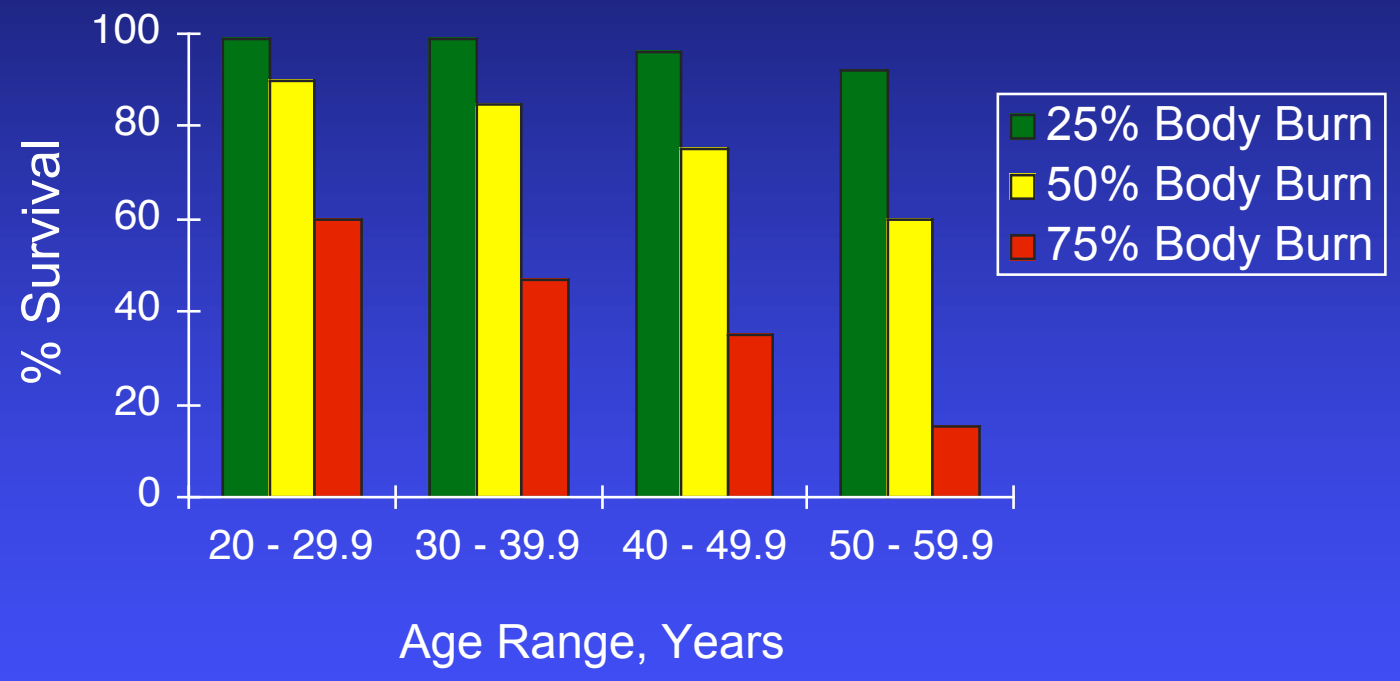
- Low Energy/Short Duration Exposures Result in Burn Injury
- 2nd Degree Burn Predicted w/6 Cycle (0.1 s), ~1 cal/cm^2 Exposure

  (Basal layer reaches ~79°C in ~0.12 s)

Flammable Clothing Ignition Highly Probable

- Can Lead to Extensive Tissue Damage (3rd Degree Burn Injuries)
- NFPA Limits Flammable Clothing < 2 cal/cm^2

BURN INJURY PRINCIPLES - SURVIVAL



American Burn Association, 1991-1993 Study

BURN INJURY PRINCIPLES - MONETARY COST

- Burn Treatment
  - ~ One Day of Hospitalization for Each % Body Burn
- Treatment Can Easily Exceed $1,000,000
- Potentially Years of Skin Grafting / Rehabilitation
- Burn Victim may Never Return to Work

Bottom Line

2nd Degree Burns - Weeks to Recovery
3rd Degree Burns - Years to Recovery (Skin Grafts ...)

BURN INJURY PRINCIPLES - PERSONAL COST

Personal Cost for Burn Victim Is Devastating

- Burns are of the Most Painful & Debilitating Injuries
- Source of Disfigurement and Intense Pain
- Depression is Common
- Impact on the Victim's Family is Profound
- Everyone is Affected

Quality of Life . . .

MATERIAL MEASUREMENT - STANDARDS

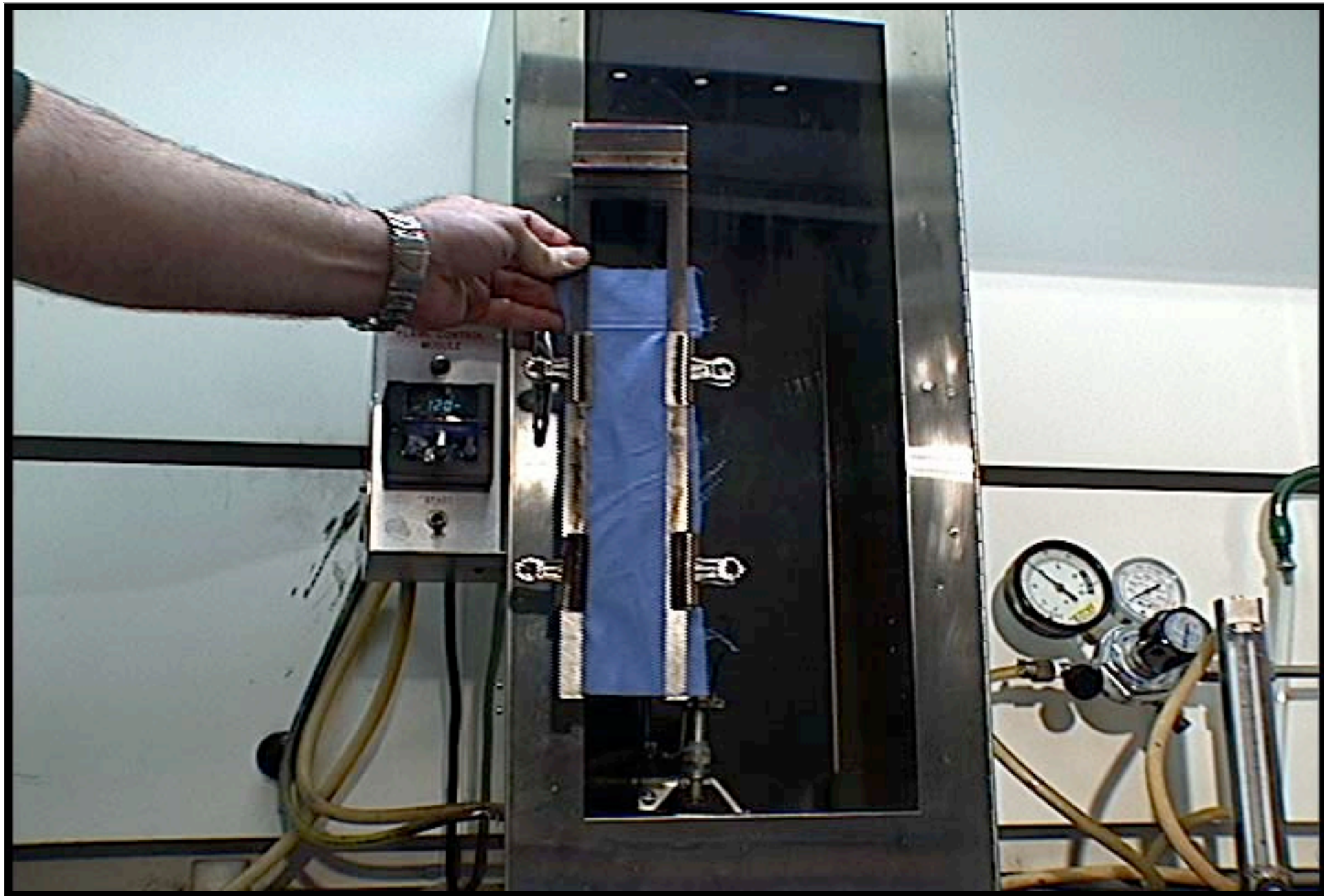
- Performance Specification
  ASTM F 1506
- Vertical Flammability
  ASTM D 6413
- Arc Rating for Clothing Materials
  ASTM F 1959
- Arc Rating for Face Protective Products
  ASTM F 2178

MATERIAL MEASUREMENT - ASTM D 6413

Vertical Flammability - Flame Resistance

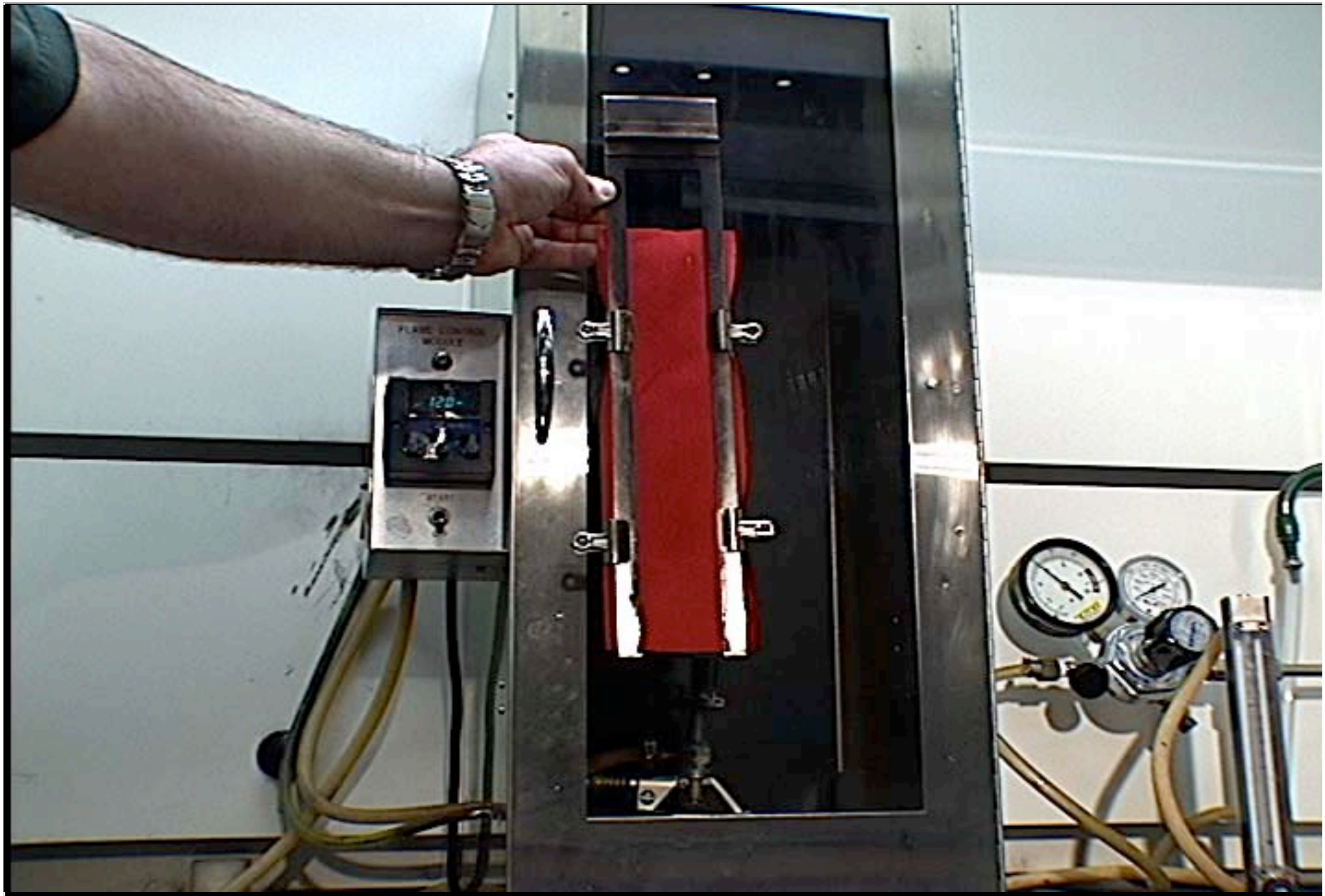
- Determine if a Fabric Burns
- Developed in 1920's
- Controlled Flame Exposure Measurement
  - Length of Burn Damage
  - Afterflame
  - Afterglow
- Material Performance Spec's Reference this Test
  - ASTM, NFPA
    - Maximum Char Length - 15.2 cm (6 inch)
    - Maximum Afterflame Time - 2 s

Will Clothing Ignite & Burn in Flame Exposure?



100% Cotton Vertical Flame Test (Shirting Weight)

© DuPont 2003



Nomex® IIIA Vertical Flame Test (Shirting Weight)

© DuPont 2003

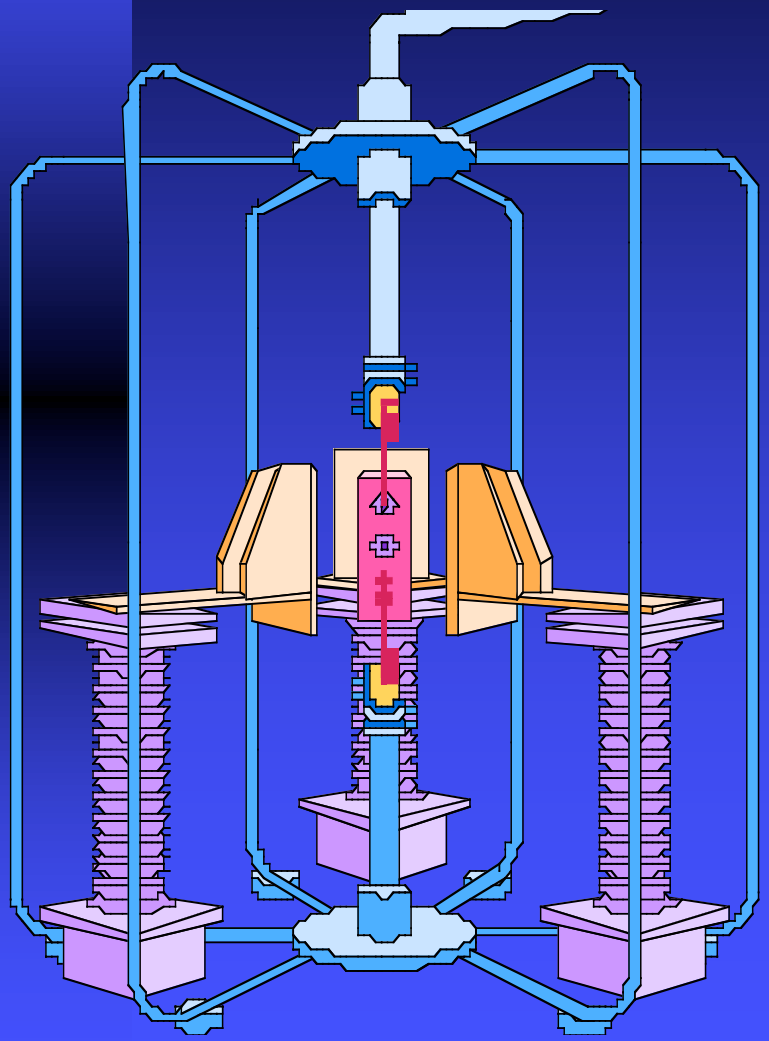
MATERIAL MEASUREMENT - ASTM F 1959

Arc Rating for Clothing Materials

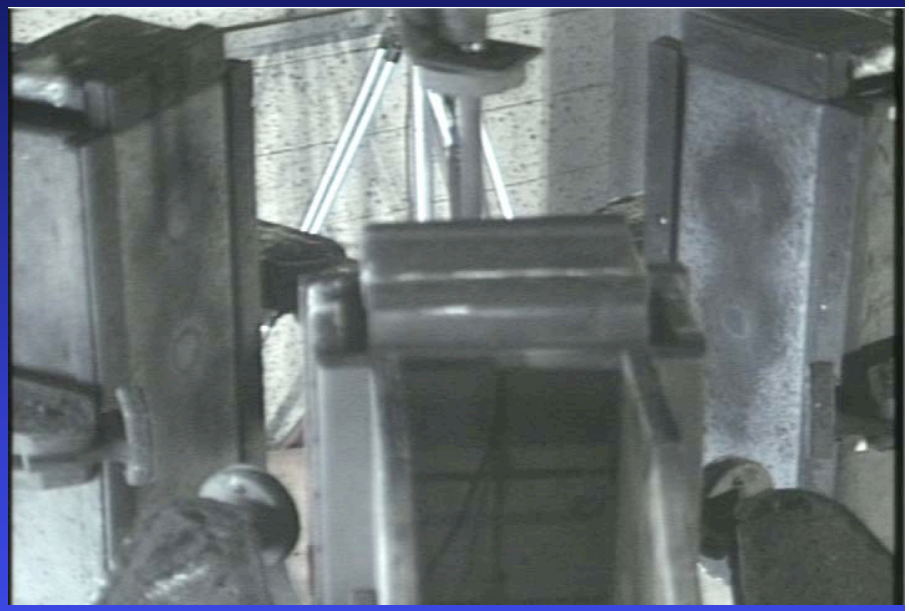
- Reference Method for Performance Criteria Standards
- Evaluates Clothing PPE Materials
  - Single & Multilayer
  - Mechanical Failure Point (Breakopen)
  - Burn Injury Onset Energy from Arc Flash (ATPV)
- Foundation for NFPA 70E PPE Requirements
- Expected Model for OSHA Regulation Revisions
- Currently Undergoing Revision

MATERIAL MEASUREMENT - ASTM F 1959

Arc Rating for Clothing Materials



Kinectrics High Current Lab
Toronto, Ontario, Canada

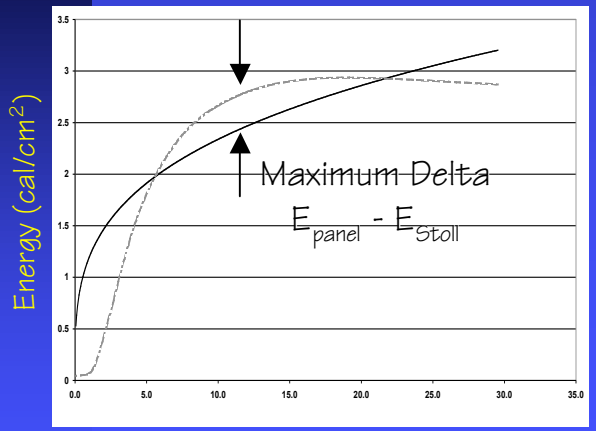


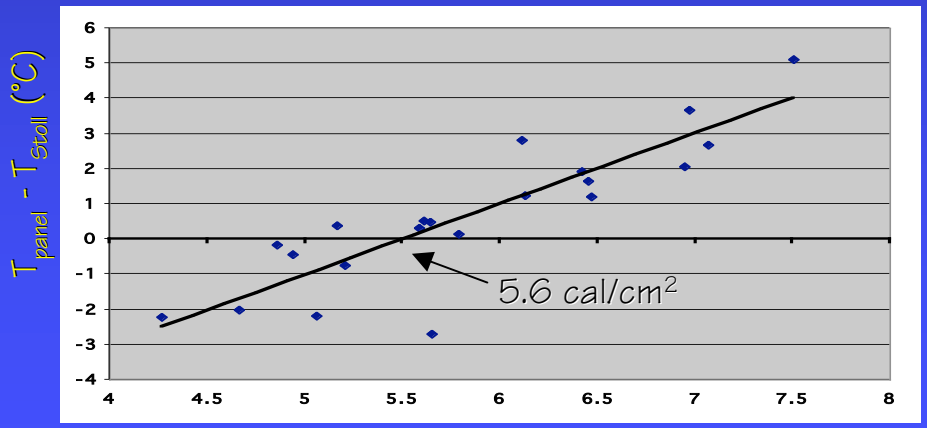
- Electric Arc Panel Test
- Fixed Fault Current (8kA) w/ Adjustable Duration, 30.5 cm (12 inch) Arc Gap

MATERIAL MEASUREMENT - ASTM F 1959

Arc Rating for Clothing Materials

- Monitor Sensors Measure Incident Energy
- Compare Panel Sensors to Stoll Curve
- ATPV - Linear Regression of 20 Panels Minimum
- Ebt - Breakopen / Ave 5 Highest Under Stoll





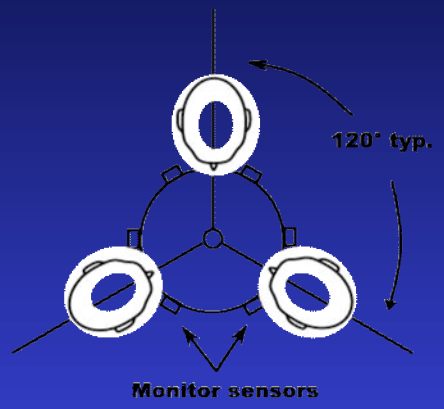
MATERIAL MEASUREMENT - ASTM F 2178

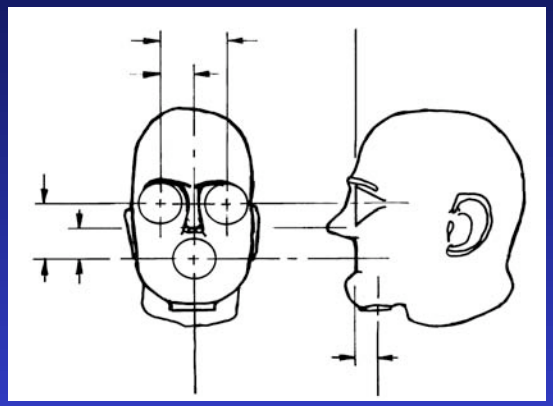
Arc Rating for Face Protective Products

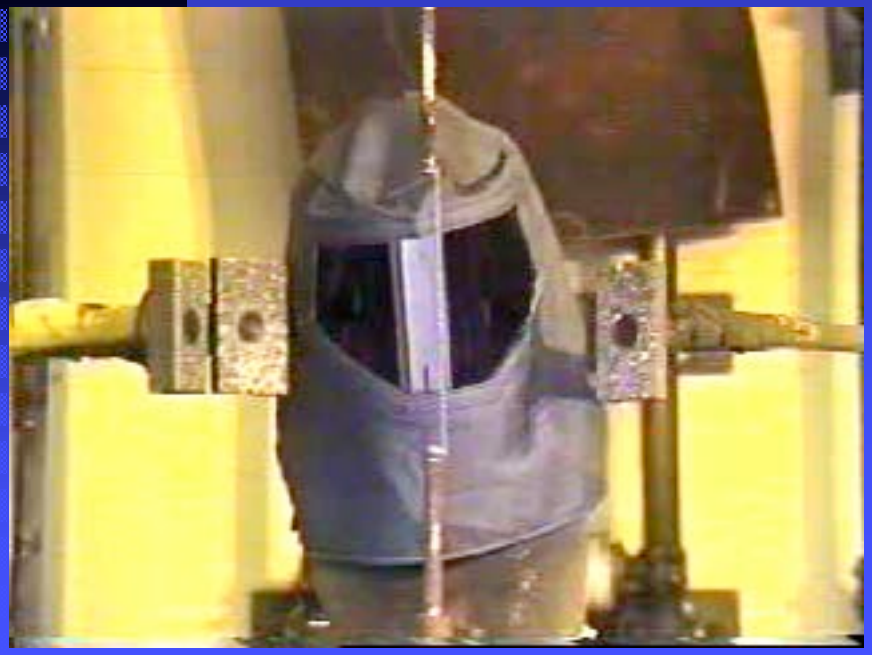
- Reference Method for Performance Criteria Standards
- Evaluates Faceshield Arc Thermal PPE Materials
  - Alone (on Hardhat, etc.) & in Hoods
  - Mechanical Failure Point (Breakopen)
  - Burn Injury Onset Energy from Arc Flash (ATPV)
- 8kA Fault Current w/ Adj Duration, 30.5 cm Arc Gap
- Foundation for NFPA 70E PPE Requirements
- Incorporates Improved Data Analysis Procedure

MATERIAL MEASUREMENT - ASTM F 2178

Arc Rating for Face Protective Products







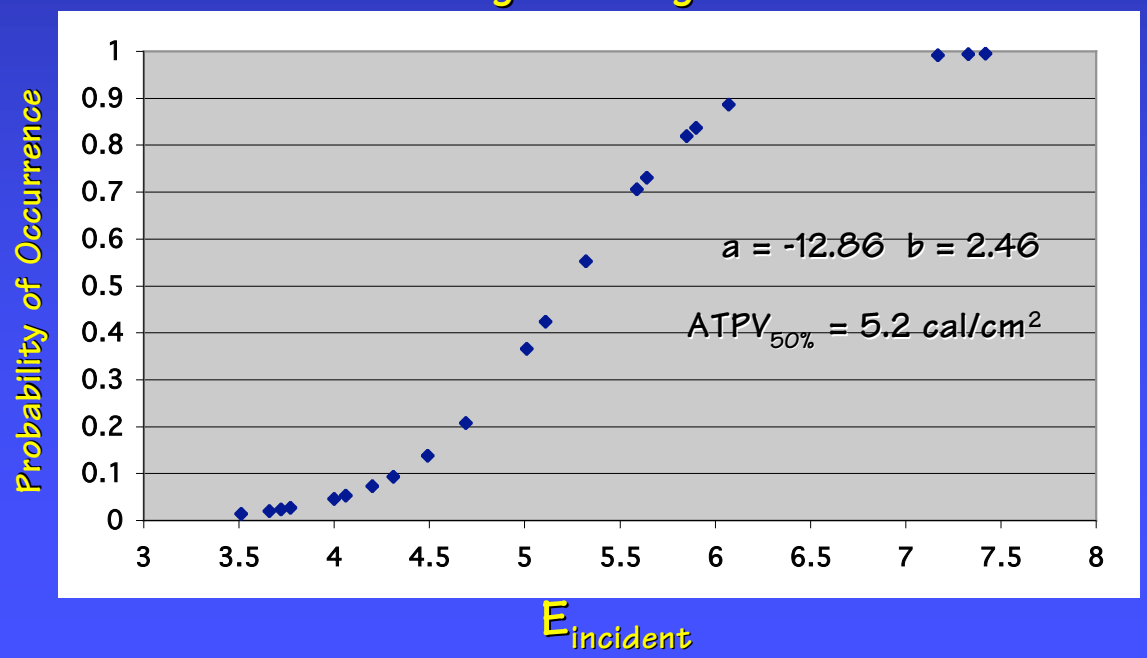
MATERIAL MEASUREMENT - ASTM F 2178

Arc Rating for Face Protective Products

- Monitor Sensors Measure Incident Energy
- Compare Highest Headform Sensor to Stoll Curve
- ATPV / Ebt - Logistic Regression 20 Samples Min

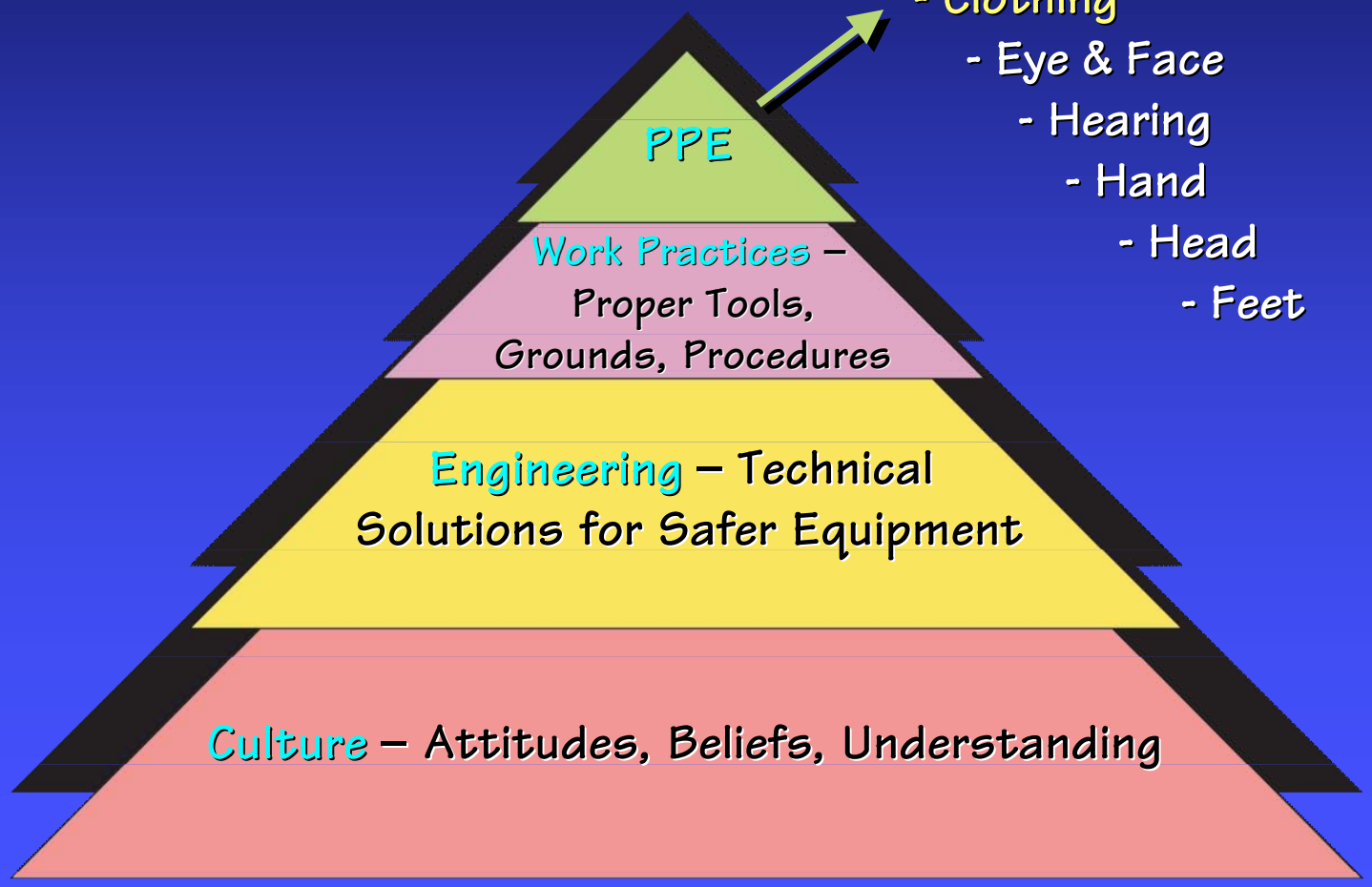
$E_{incident}$	Over Stoll?
7.33	1
7.42	1
7.17	1
5.9	1
5.32	0
5.59	1
3.51	0
4.06	0
4.2	0
4.69	1
6.07	1
4.49	0
5.64	1
5.01	0
4.31	0
5.11	1
5.85	0
4	0
3.66	0
3.72	0
3.77	0

ATPV Logistic Regression Plot



PPE CONSIDERATIONS - GENERAL

Electrical Safety Program



Personal Protective Equipment

- Clothing
- Eye & Face
- Hearing
- Hand
- Head
- Feet

PPE CONSIDERATIONS - IMPLEMENTATION

- Determine the Appropriate Clothing for the Hazards
- Educate & Train for the Need to Wear Flame Resistant Clothing
- Design a Program to Achieve Acceptance Among the Workforce
- Establish Care & Maintenance Practices

Key Elements for Success

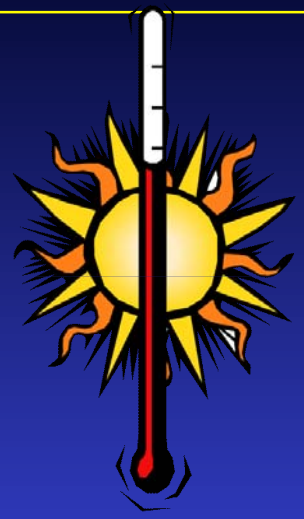
PPE CONSIDERATIONS - IMPLEMENTATION

Selection Criteria

- Protection / Compliance
- Comfort / Dexterity
- Durability
- Appearance
- Cost Effectiveness
- Ease of Care

PPE CONSIDERATIONS - SELECTION

Thermal Performance Requirements



- Does Not Ignite & Burn, Melt or Drip
- Resists Breakopen
- Maintains a Barrier to the Thermal Exposure
- Establishes an Air Layer Between Skin & Material
  - Fit / Sizing Important - Loose, Not Tight to the Skin
- Performance Exceeds Thermal Threat
  - Remember the Arc Rating is the 50% Probability of Failure

Bottom Line - Proper PPE

Reduces Burn Injury
Increases Survivability
Reduces Cost Consequences of Event
You MUST Understand the Thermal Threat

PPE CONSIDERATIONS - SELECTION

Layering & Thermal Performance

ATPV
~12 cal/cm^2
to
4 cal/cm^2

Single Layer FR Garments

+

ATPV
~16+ cal/cm^2
to
~8 cal/cm^2

Two Layer / FR + Cotton

or

+

ATPV
~35+ cal/cm^2

Three Layer
FR +FR + Cotton

PPE CONSIDERATIONS - SELECTION

Layering & Thermal Performance - Specific Examples

System Description	Layers	Weight oz/yd^2	Value cal/cm^2
Nomex® IIIA Coverall	1	7.5	7.0
Cotton T-Shirt Nomex® IIIA Coverall	2	12.0	15.6
Cotton T-Shirt Nomex® IIIA Coverall Nomex® IIIA Coverall	3	19.5	39.9
Cotton T-Shirt Nomex® IIIA Shirt Nomex® IIIA Coverall Nomex® IIIA Coverall	4	24.0	>50

NFPA 70E
2004 Edition

PPE Requirements
Clothing

PPE CONSIDERATIONS - NFPA 70E

General Information

- Standard for Electrical Safety Requirements
- Most Comprehensive Electrical Safety Std Available
- Developed Primarily by Electrical Engineers
- 120+ Pages of Detailed Requirements and Info
- Covers All Aspects of Workplace Electrical Safety
- ~10 Pages Dealing with Protective Clothing
- PPE Based on Arc Hazard Analysis
  - Clothing is Selected Against the Exposure Level

PPE CONSIDERATIONS - NFPA 70E

Recent History

1995 NFPA 70E Defines Arc Flash Boundary

1997 DuPont Arc Protective Clothing Research Published

1998 ASTM F1506 & F1891 for FR Clothing and Rainwear

1999 FR Clothing Makers begin to Provide Arc Rating

1999 ASTM F1959 Arc Test Method Issued

2000 NFPA 70E Incorporates Technical Developments

2002 ASTM F2178 for Face Protective Products

2002 ASTM F1506 & F1891 Revised

2004 NFPA 70E Emphasizes Safe Work Practices

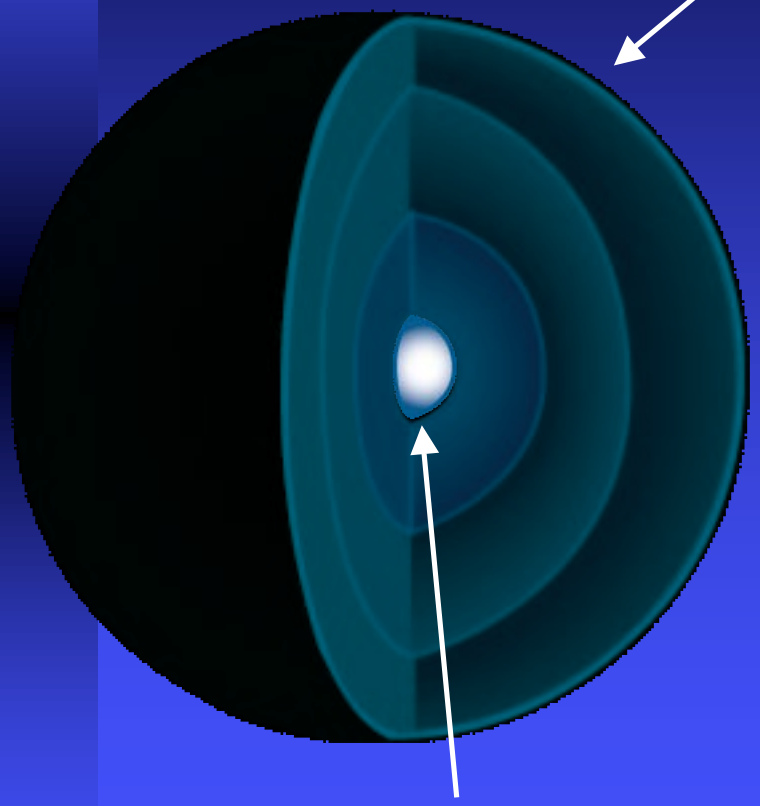
PPE CONSIDERATIONS - NFPA 70E

NFPA 70E - Key PPE Selection Steps

- Arc Flash Hazard Analysis / Work Permit *[130.1 (A) & .3]*
- Arc Flash Protection Boundary Determined *[130.3 (A)]*
- PPE Identified Based on Hazard Presented *[130.3 (B)]*
  - 2 Methods to Determine Hazard Magnitude
    - Calculate Exposure Energy Based on System Knowledge *[130.3 (B)]*
    - *or*
    - Utilize Hazard Risk Category Classifications *[130.7 (C)(9)]*
  - 3 Methods for Clothing Selection
    - A. Based on Calculated Exposure Energy *[130.3 (B)]*
    - *or*
    - B. Using Hazard Risk Category PPE Matrix *[130.7 (C)(10)]*
    - *or*
    - C. Using Simplified Hazard Risk Category Matrix *[Annex H]*

PPE CONSIDERATIONS - NFPA 70E

Flash Protection Boundary Considerations



- Calculated for Each Task
- Outside 2nd Degree Burn
  Injury Not Expected
  FR PPE Not Required
  Burn Injury Can Occur
- Inside 2nd+ Degree Burn
  Injury Predicted
  FR PPE Required
- PPE Needs May Differ For Body Parts
  Arms & Hands

PPE CONSIDERATIONS - NFPA 70E

Protective Clothing / PPE Matrix

[Table 130.7 (C)(10)]

- Personal Protective Clothing
  - Untreated Natural Fiber Underlayers
    T-Shirt, Shirt (Long Sleeve), Pants (Long)
  - Flame Resistant Outerlayers
    Shirts, Pants, Coveralls, Jacket, Parka, Rainwear
- FR Protective Equipment
  - Flash Suit — *Multi-layer Jacket & Pants*
  - Head Protection — *Hard Hat, FR Lined Hard Hat*
  - Eye Protection — *Safety Glasses / Goggles*
  - Face/Head Protection — *Face Shield & Switching Hood*
  - Hearing Protection — *Ear Canal Inserts*
  - Hand Protection — *Voltage Rated / Leather Gloves*
  - Foot Protection — *Leather Work Shoes*

NFPA 70E - Forbidden Materials

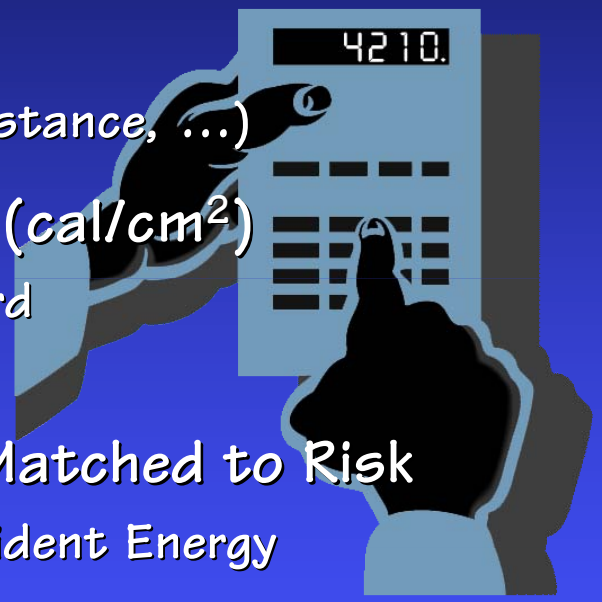
- Synthetic Materials Posing Melt Hazard [130.7 (C)(14)(a)]
  - Polyester
  - Nylon
  - Polypropylene
  - Spandex
  - Cotton Blends of Above
- 29 CFR 1910.269 Identified Materials
  - Acetate
  - Nylon
  - Polyester
  - Rayon
  - Cotton Blends of Above

- Clothing that:
  - Does not meet ASTM F1506 [130.7 (C)(14)(a)]
  - For HRC 0 & -1 not meeting ASTM F 1958 @ 2 cal/cm^2 [130.7 (C)(15)]

PPE CONSIDERATIONS - NFPA 70E

Arc Hazard Method A - Direct Calculation

- Electrical Resource Conducts Task Hazard Analysis
  - Electrical parameters
  - Equipment configuration
  - Permitted Task Work Rules (Approach Distance, ...)
- Arc Flash Incident Energy Predicted (cal/cm^2)
  - NFPA 70E Equations, IEEE 1594 Standard
  - Commercial Software
- Clothing System Arc Rating (ATPV) Matched to Risk
  - Rating Should Exceed the Estimated Incident Energy
  - No Minimum Arc Rating for Method A
  - Hands / Arms Protection Requirements Easily Determined



Considered the Optimum Method for the Arc Hazard

PPE CONSIDERATIONS - NFPA 70E

Arc Hazard Method B - Hazard/Risk Category Classification

- Electrical Resource Elects No Hazard Analysis [130.7(C)(9)]
  - Flash Protection Boundary Still Determined
  - NFPA 70E Tables Used for Task Risk & PPE
    - Hazard Risk Category Classification Table
    - Protective Clothing & PPE Matrix
- *Hazard Risk Category Identified (0 to 4)* [Table 130.7(C)(9)(a)]
- PPE Identified According to Matrix [Table 130.7(C)(10)]
- Minimum ATPV Requirements Table Lookup [Table 130.7(C)(11)]

  4 cal/cm^2 for Cat 1, 8 cal/cm^2 for Cat 2

  25 cal/cm^2 for Cat 3, 40 cal/cm^2 for Cat 4
- *Some Degree of Over Protection versus Method A*
- *Must Estimate Hands / Arms Protection*

PPE CONSIDERATIONS - NFPA 70E

Arc Hazard Method B - Hazard/Risk Category Classification

Table 130.7(C)(11)

Hazard / Risk Category	Clothing System Description (No. of Layers)	Minimum ATPV / E_{bt} cal/cm^2
0	Non-Melting/Non-Flammable material, > 4.5 oz/yd^2 (1)	N/A
1	FR Shirt & Pants or FR Coverall (1)	4
2	Cotton Underwear (Short Sleeve T-shirt & briefs) FR Shirt & Pants or Coverall (1 or 2)	8
3	Cotton Underwear FR Shirt & Pants + FR Coverall (or 2 pair of Coveralls) (3)	25
4	Cotton Underwear FR Shirt & Pants Multi-Layer Flash Suit (3 or more)	40

PPE CONSIDERATIONS - NFPA 70E

Arc Hazard Method B - Hazard/Risk Category Examples

1

2

3 & 4

PPE CONSIDERATIONS - NFPA 70E

Arc Hazard Method C - Simplified Hazard/Risk Category

- Electrical Resource Elects No Hazard Analysis
  - Flash Protection Boundary Still Determined
  - NFPA 70E Simplified 2 Category System Used

    Annex H, Table H-1

    Combines Category 1 & 2 from Method B

    Combines Category 3 & 4 from Method B

- Everyday Work Clothing Identified as 8 cal/cm^2
- Electrical Switching Clothing 40 cal/cm^2
- *Generally Over Protects versus Methods A or B*
- *Hands / Arms Protection Estimation More Difficult*

PPE CONSIDERATIONS - NFPA 70E

Arc Hazard Method C - Hazard/Risk Category Simplified

Table H.1

Clothing Category	Minimum ATPV or E_{BT} cal/cm^2	Protective Clothing Systems Which Meet NFPA 70E Requirements
Everyday Work Clothing	No Minimum Similar to Hazard Risk Category 2	FR Shirt (min. ATPV of 4) Worn Over a Cotton T-shirt with FR Pants (min. ATPV 8) Or FR Coverall (min. ATPV of 4) Worn Over a Cotton T-shirt (or Cotton Long Sleeve Shirt) and Cotton Work Pants
Electrical Switching Clothing	No Minimum Similar to Hazard Risk Category 4	Multi-layer FR Flash Jacket & FR Bib Overalls Over FR Coverall (min. ATPV of 4) Over Long Sleeve Cotton Shirt and Cotton T-Shirt and Cotton Work Pants Or Insulated FR Coverall (min ATPV of 25) Over Long Sleeve. Cotton Shirt, T-shirt, & Jeans

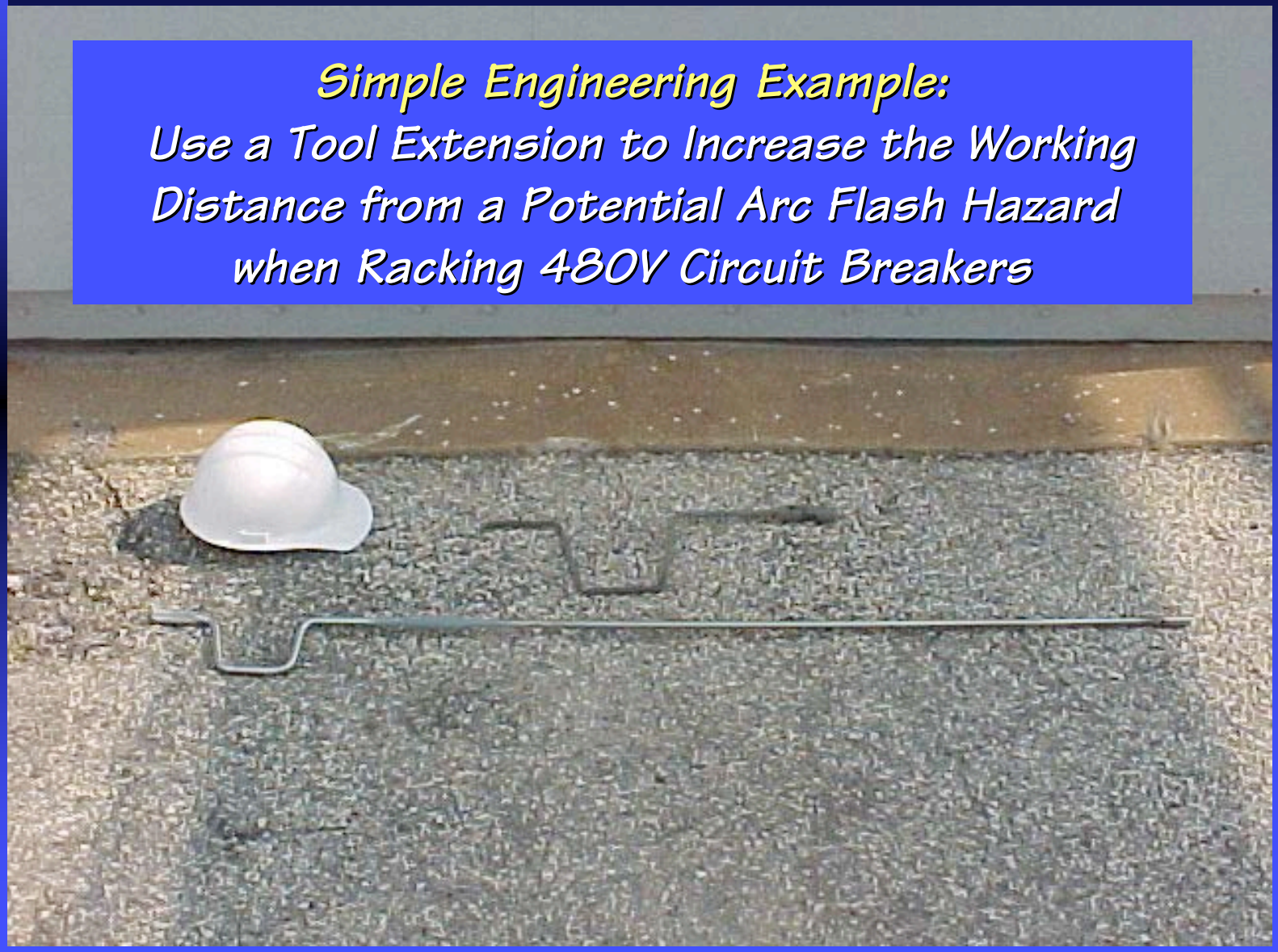
COMMON SENSE PPE GUIDELINES

- *Consider Working De-energized*
- *Implement Engineering Options to Reduce Hazard*
- *Make Sure Employee can Function with PPE*
- Use Proper Selection & Wearing Procedures
  - Select PPE for Worst Case Exposure (+ Arms & Hands)
  - Allow for a Safety Margin in Arc Rating of Clothing
  - FR Workwear Should Provide Good Functional Fit
  - Loose Fit Gives Additional Thermal Protection
  - Fully Buttoned Shirt, Sleeves, and Outerwear
  - Wear PPE for Neck, Face, Head, Hands, & Feet
- Outerwear Must be Flame Resistant
  - Flammable Outerwear Can Ignite & Burn
  - Eliminates Protection of FR Clothing Underneath

ELECTRIC F·I·R·E

COMMON SENSE PPE GUIDELINES

Simple Engineering Example:
Use a Tool Extension to Increase the Working Distance from a Potential Arc Flash Hazard when Racking 480V Circuit Breakers



New Standards & Updates

- **ASTM F 1959 Revision Nearly Completed**
  - Revised Sensor Design
  - Breakopen Treated as Material Characteristic
  - Extended the Method Utility - Ignition Point
  - Significantly Improved Data Analysis Method
  - Probability Information Now Determined
  - Precision Statement Being Developed
- **New ASTM F18.65 Manikin Arc Test in Development**
  - Goal to Evaluate Garment Construction Characteristics
- **ASTM F18 Arc Blanket Subgroup Working on Standard**
  - Currently Working to Establish Hazards to Test Against
- **ASTM Proposals to Capitalize on Probability Information**
  - A Few Mfgr's are Incorporating Probability Info in Labeling

YOU'RE NOW EXPERTS!

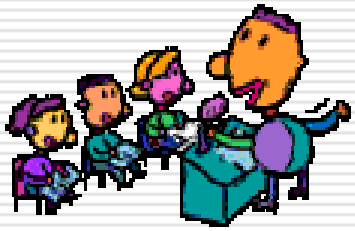
BURN INJURY & MATERIAL MEASUREMENT FUNDAMENTALS

SELECTION OF PROTECTIVE CLOTHING & NFPA 70E

Live Work and Electrical Safety

Presented by: Ed Hunt

I’m not a professional speaker!



Career Profile

- Started in Line work as a Groundman at the City of Longmont CO in 1983.
- Started with Western in 1992 as a lineman.
- Foreman II in 1996.
- Foreman III in 2003.

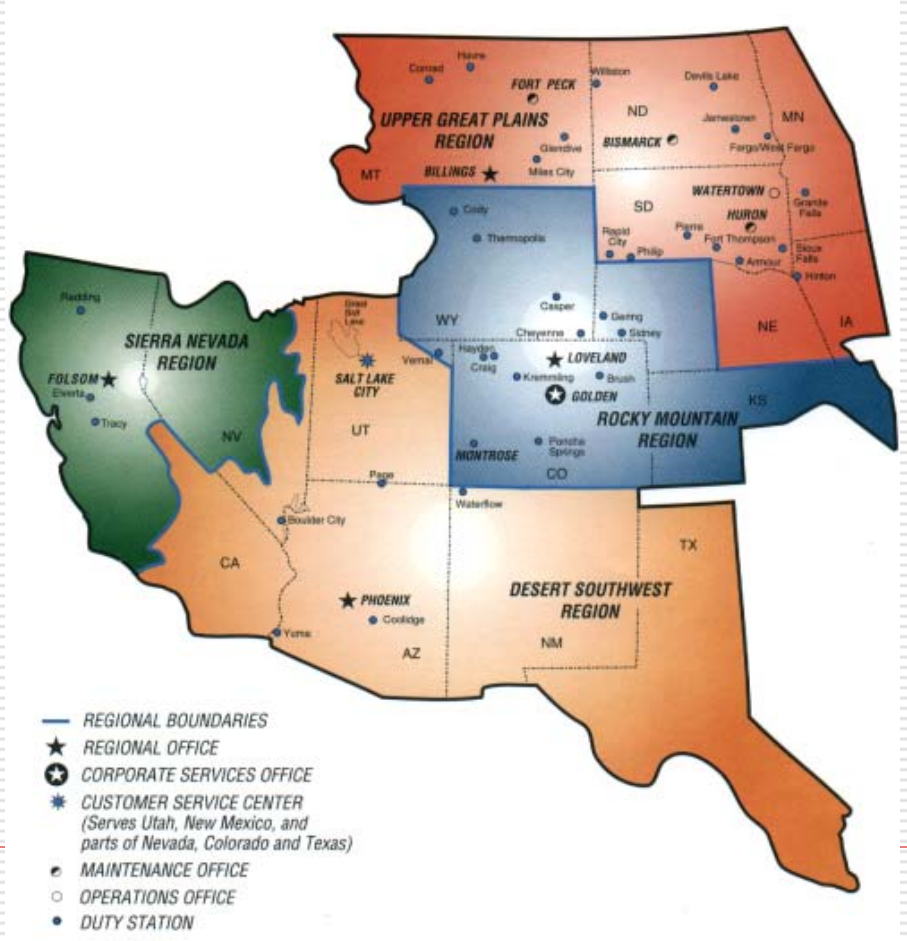
Professional Committees

- IEEE / ESMOL
  - Creating and maintaining of Electrical Safety standards.
- NESC, Sub committee 8
  - Creation and maintenance of Safety Code.
- EPRI Live Working WG
  - Represent Westerns interest in base funded research and development.

Who is Western Area Power?

- Western is one of Four DOE Power Marketing Agencies (PMA's).
- Western's service area covers 1.3 million square miles.
- Western maintains over 16,000 miles of Federally owned transmission lines.
- Western sells power to 636 preferred wholesale customers.

Where is Western Area Power?



Remote Lines

Western Trivia

- Western is the only PMA doing Barehand
- In 1948 Western (formerly the Bureau of Reclamation) changed out suspension insulators using the hot stick method on 287KV at Hoover Dam
- In the early 1970's Western experimented with Live Working in substations
- In the late 1990's Western utilizes Portable Protective Air Gaps to perform Live Work

Barehand Definition

- A technique of performing live line maintenance on energized conductors and equipment whereby one or more authorized persons work directly on an energized part after having been raised and bonded to the energized conductors or equipment.

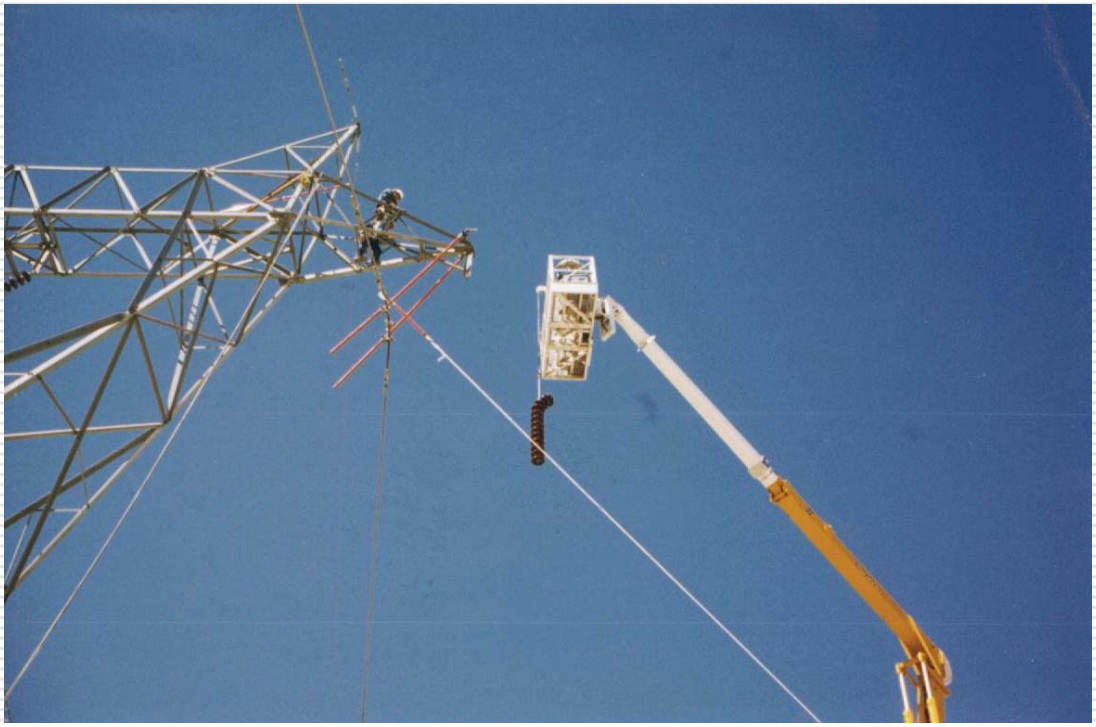
What is Live Working?

- Performing work on Power lines while they remain energized.
- Different methods for different voltages.
- The methods used above 69K can be:
  - Hot-stick Method
  - Bare-hand Method
  - Combination (Most Common)

Hot-stick Method

Barehand Hot-stick Method

Use of Bucket Truck



Why Live Working?

- De-energizing not possible due to system configuration and line loading.
- Radial feeds.
- Keeps employees proficient at their craft.
- RTO/ISO constraints
  - No touch days in California are a good indicator of the new wave of system control.

Why Live Working?

- Eliminates the need for travel to remote switching locations.
- Saves loss of income due to no power flowing to potential customers.
- Reduces scheduling problems with multiple lines being de-energized.

Key Safety Considerations in Live Work

- What is your safe approach distance?
- What is your Arc Flash Hazard?
- Fall Protection requirements?
- Work Procedures on hand?
- JHA Complete, Reviewed and Initialed?
- Emergency response plan in place?
- Positive communications established?

Potential Hazards

- Falling
- Violating MAD
- Injury in air, requiring an aerial rescue
- Stick flashing over at work site
- Rigging letting loose
- Over voltage situation caused by lightening or switching

Preparations

- Insure Hot-sticks have passed the required electrical stress tests within the mandatory two year time period.
- Identify the procedure to be performed.
  - Review this procedure in written form
    - If necessary, update procedure
    - Obtain Maintenance Manager approval.

Written Procedures

Procedure BB
Revised
June 10, 1991

DEPARTMENT OF ENERGY
WESTERN AREA POWER ADMINISTRATION
LOVELAND AREA OFFICE

COMBINATION HOT-STICK AND BAREHAND
TRANSMISSION LINE PROCEDURE WITH INSULATED LADDER

DEADEND INSULATOR STRING REPLACEMENT
230 KV STEEL-TOWER STRUCTURE
SINGLE-CIRCUIT -- ALL PHASES
DOUBLE-CIRCUIT -- ALL PHASES
SINGLE-STRING DEADEND
DOUBLE-STRING DEADEND
WITHOUT HOT LINE FITTINGS

BASIC CREW:

1 - Foreman
4 - Linemen
3 - Groundmen

RECOMMENDED TOOLS AND EQUIPMENT:

1 - Regular handline
1 - Dropline
1 - Nonconductive handline
2 - 1/2" nonconductive rope taglines
1 - short 1/2" nonconductive rope tagline
1 - 1/2" rope sling
1 - 1/4" rope sling
1 - 1-1/4" x 12' universal pole - spliced fiberglass ladder section(s)
1 - rigid ladder splice, consisting of two removable rigid aluminum tubes and 8 pins with safety pins
2 - 1-1/2" x 12' swivel sticks
1 - Spreader bar
4 - 2-1/2" ladder clamps
1 - Horizontal tower attachment, complete with yoke and clamping features
1 - Shepherd hook
1 - 20' telescoping fiberglass measuring stick
1 - 50' telescoping fiberglass measuring stick
1 - 24" nylon cargo sling

1

Recommended Tools and Equipment (Cont.)

1 - Nonconductive rope blocks
1 - 3/8" x 4' wire rope sling or 4' nylon cargo sling
1 - Small steel shackle
1 - Ladder monitor kit
1 - Meter-type insulator tester
1 - Static ground, equipped with flat-face clamp
1 - Static ground, equipped with conductor clamp
3 - Canvas tool bags
1 - Electric-powered capstan hoist
1 - Bonding clamp
1 - Safety strap hook
- hand tools

STATIONARY INSULATOR CRADLE:

1 - 230-KV - length as required

SINGLE-STRING DEADEND:

1 - 2" adjustable strain carrier pole --- 230-KV
1 - Large trunnion
1 - 2" lock-type adjustable pole clamp
1 - 2" wire tong band
2 - Double-string yokes, each equipped with 2 removable eye bolts
2 - Double-string yoke pins
1 - Ratchet wrench

DOUBLE STRING DEADEND:

2 - 1/4" rope slings
2 - 2" adjustable strain carrier poles --- 230-KV
2 - Small trunnions
2 - 2" lock-type adjustable pole clamps
2 - 2" wire tong bands
1 - Hot-end yoke, equipped with 2 removable eye bolts
1 - Socket eye
1 - Ball hook
1 - Yoke, equipped with 2 removable eye bolts and strap
1 - 3/4" x 6" clevis bolt
1 - 6' steel chain, equipped with grab hook
2 - Ratchet wrenches
1 - Wire grip (proper size for conductor)

PROCEDURE

1. Secure a Hot-Line Order. Always maintain minimum working and clear hot-stick distance for voltage worked.

2. Assemble a stationary insulator cradle for voltage and insulators of the line being worked on.

2

3. SINGLE-STRING DEADEND -- Assemble one deadend assembly, consisting of one 2" adjustable strain carrier pole of the proper length for the voltage being worked, fitted with one large trunnion on the threaded adjusting end, one 2" wire tong band mounted near the adjusting end, and one 2" lock-type adjustable pole clamp mounted on the pegged end.

4. DOUBLE-STRING DEADEND -- Assemble two deadend assemblies, consisting of one 2" adjustable strain carrier pole of the proper length for the voltage being worked, fitted with one small trunnion on the threaded adjusting end, one 2" wire tong band mounted near the adjusting end, and one 2" lock-type adjustable pole clamp mounted on the pegged end.

5. Attach an electric-powered capstan hoist to a tower leg or other suitable mounting at the ground position.

6. The linemen selected to work on the tower, carrying a dropline, climb the tower to the area of the insulated ladder attachment point; pull up and secure a handline to the tower well above the insulated ladder attachment point.

7. Raise a telescoping fiberglass measuring stick to the linemen on the tower. The linemen on the tower will determine and mark the point of attachment for the horizontal tower ladder assembly. The linemen on the tower, using the telescoping fiberglass measuring stick, should carefully measure from the predetermined ladder attachment point to the desired working position. Lower the telescoping fiberglass measuring stick to the ground.

8. Select a 1-1/2" x 12' universal pole and raise to lineman on tower

9. Place a meter-type insulator tester in a canvas tool bag and raise to the linemen on the tower. The linemen on the tower should attach the insulator tester to one end of the universal pole and test each individual insulator of each insulator string in the deadend to be worked on, starting at the "hot" end of the insulator string(s) and working back to the tower end. The meter readings for bad insulators should be recorded. If the insulator string(s) are within the limitations set forth in Subsection 9.1.13 of the "Power System Safety Standards," remove the insulator tester from the universal pole, place it in the canvas bag and lower to the ground, and continue with the work program.

10. Assemble the insulated ladder on the ground. Select the proper spliced fiberglass ladder section(s) for the measured distance from the insulated ladder attachment point to the desired working position. Attach two 2-1/2" ladder clamps to the spliced fiberglass ladder section(s) at the measured distance from the selected mounting end. Engage a 1-1/2" x 12' swivel stick to each ladder clamp. Attach a spreader bar to the open butt ring of each swivel stick. Temporarily tie the spreader bar to the fiberglass ladder. Attach two

3

3 pages of an 8 page procedure

230KV Center Phase

Develop Written JHA

WAPA F 5530.55 (6-91)

U.S. DEPARTMENT OF ENERGY
WESTERN AREA POWER ADMINISTRATION
JOB HAZARD ANALYSIS

JHA No. _____

Activity Description: Hot Crossarm Replacement		Routing:
Activity Location: HJ-MM 115K	Date of Activity: 8/16/00	Safety Manager
JHA Prepared by: Ed Hunt	Date: 8/16/00	Division Director
Joint JHA considered? (Yes, if more than one discipline is involved)		
Are written procedures required? If so, attach copy.		
PERSONNEL INVOLVED (include engineers, other crafts, and other agencies)		JHA Review Date:
Responsible Job Supervisor:		

WORK CREW				OTHER PERSONNEL	
Name	Init.	Name	Init.	Name	Init.
Ed Hunt		Wayne Newton			
Tim Smith		Elton John			
Ron Jeakee		Boy George			
Tom Armstrong					

LIST OF SPECIAL EQUIPMENT AND TOOLS:
Hotsticks, Captain

SPECIAL INSTRUCTIONS OR LIMITATIONS: Consider: (1) Energized equipment (2) Experience of work crew (3) Engineering expertise available (4) Clearances and grounding requirements (5) Emergency capabilities such as CPR, First Aid (6) List applicable sections of such standards as PSSM, PSOM.

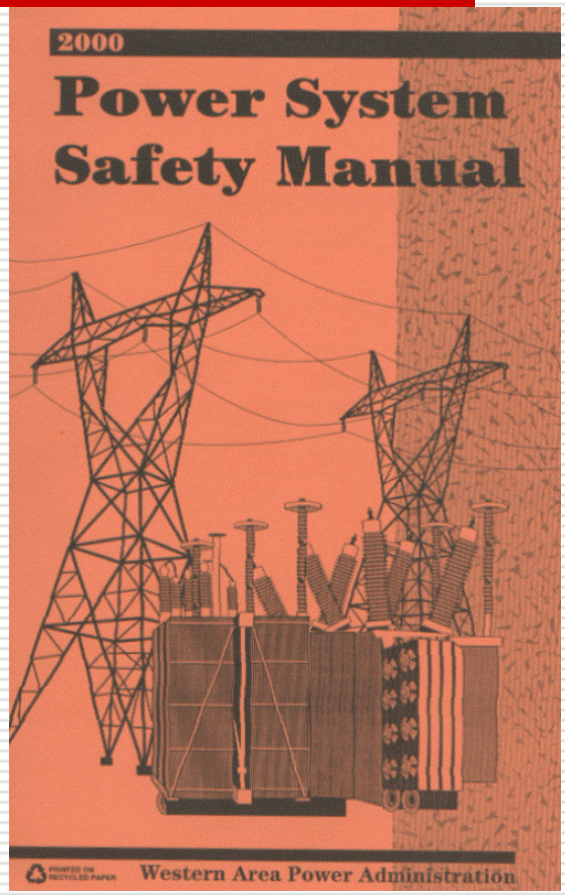
HLD # HOD-060 issued @ 800HRS to Ed Hunt
Work location Lat / Long
PSOM Chapter 13

LIST OF IDENTIFIED HAZARDS AND HOW TO MINIMIZE OR ELIMINATE THEM

ACTIVITY	IDENTIFIED HAZARDS	CORRECTIVE ACTION
Rigging	Rigging not holding	Inspect all equipment Prior to use
Hotsticking	Choking stick Electrician	Wipe down sticks Don't choke sticks Maintain MAD of 3'4"
Climbing	Cutting out falling	Use proper climbing techniques Make use of fall protection

(USE BACK SIDE IF ADDITIONAL SPACE IS NEEDED)

PSSM (Safety Manual)

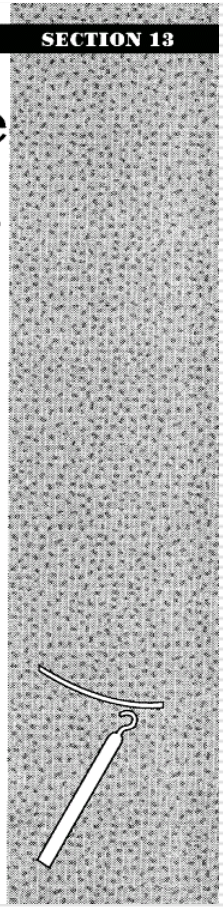


Understand Sections 13 and 14

SECTION 13

Live-line Hotstick Work

13.1 General
13.2 Inspecting, Testing, and Maintenance of Hotsticks
13.3 Other Tools
13.4 Hotstick Techniques
13.5 Erection and Removal of Poles



SECTION 13
LIVE-LINE HOTSTICK WORK

This section includes precautions that are to be taken when performing maintenance or associated training using hotstick methods on energized transmission lines. Further guidelines are provided in Western's Power System Maintenance Manual (PSMM), Chapter 3, "Live-line Maintenance" (latest revision). This section does not apply to general switching or fuse replacement.

13.1 GENERAL.

a. An agency certification must be obtained in order for workers to perform or supervise hotstick work, except during training sessions when working under constant supervision.

b. Hotstick work is to be personally supervised by a supervisor who is trained and certified to direct that specific type of live-line work.

c. Specific written job procedures are to be reviewed, updated as necessary, and discussed with the crew before work begins.

d. The supervisor shall receive a HLO on the involved circuit(s) and shall remain at the jobsite in non-work status while procedural live-line work is in progress. He shall be positioned to observe and direct all aspects of the live-line work.

e. Use only equipment and tools that are rated for the voltage of the line/equipment.

f. Use electrically tested and visually inspected fiberglass-reinforced plastic (FRP) hotsticks. Wooden hotsticks are prohibited.

g. Discontinue hotstick work while there is any indication of lightning or other inclement weather in the surrounding area.

h. Do not park vehicles under conductors except when essential for the work being performed.

i. Vehicles, with an uninsulated or insulated boom, shall be grounded with a ground cable rated for the maximum

PSSM (continued)

anticipated fault current. The vehicle shall be grounded to the structure ground system where practicable. If a worker can simultaneously contact separate ground systems, the systems shall be bonded together.

When grounding to the structure is not practicable, such as during in-span repair work, the vehicle shall be bonded to a ground rod installed near the center of the vehicle. If grounding during in-span repairs is not possible, the operator shall remain on the vehicle or on insulated or bonded conductive mat and no one shall approach within 10 feet of the vehicle or a clearance shall be taken and the vehicle shall be grounded in accordance with 10.9.a..

13.2 INSPECTION, TESTING, & MAINTENANCE OF HOTSTICKS.

a. Visually inspect and clean hotsticks and associated equipment before use. Tag defective or damaged items and remove them from service. Look for the following types of defects:

(1) A loss or deterioration of the glossy surface on hotsticks.

(2) Deep cuts, scratches, nicks, gouges, dents, or delamination in the surface.

(3) Bent, worn, cracked components, or other damage.

(4) Dirt, paint, creosote, grease, or other foreign material.

(5) Known or suspected physical or electrical overloading, as evidenced by elongated or damaged rivets or electrical tracking respectively.

b. Clean hotsticks with manufacturer's approved cleaning cloth and solution only.

WARNING: Do not use soap or liquid detergents such as 409, Fantastic, Ajax, etc., to clean hotsticks as they can leave a conductive coating.

c. Use the manufacturer's gloss-restorer products on hotsticks after cleaning only as necessary to maintain their glossy surface.

d. Dielectrically test fiberglass-reinforced plastic live-line tools at least every 2 years in accordance with PSMM, Chapter 3, Live-Line Maintenance (latest revision).

e. Transport and store hotsticks in weatherproof boxes or bags, or in tool trailers.

f. Mark hotsticks (work sticks) to identify the minimum phase-to-ground minimum approach distance listed in Appendix A for the circuit being worked.

13.3 OTHER TOOLS.

a. Use high-quality, properly maintained synthetic rope for handlines and taglines (not natural-fiber rope) for live-line work. Keep it stored in a clean, dry location and protected from damage and contamination.

b. Wear clean gloves when handling these lines to avoid contaminating them and remove wet, dirty, or damaged lines from service.

c. Maintain the minimum approach distances from energized parts listed in Appendix A when using handlines and taglines.

d. Use a tool bag to raise, carry and hold tools that are not carried in a tool belt while working from a structure or aerial device.

13.4 HOTSTICK TECHNIQUES.

a. Use metal wire or braid, as detailed in PSMM Chapter 3, "Live-line Maintenance" (latest revision), to jumper across ropes or nylon straps that are used as part of the hotstick support system of energized conductors, if the system is to be left in place overnight or longer.

b. Electrically test each porcelain or glass insulator in the insulator string(s) on tension structures (dead-ends and angles) prior to replacing insulators, wood poles, or crossarms . If any insulator string has less than the following number of good insulators listed in the following table, it is only to be replaced under deenergized conditions. Insulator units to be shunted with a static ground or that are effectively spanned by conductive parts of live-line tools are to be treated as defective.

PSSM (continued)

TABLE 13.1
MINIMUM INSULATION

Phase-to-Phase Voltage – kV	Minimum Required Number of Electrically Good Insulators for Live-Line Replacement (see note 1)	
	Porcelain	Glass
34.5 - 72.5	2	Deenergize
72.6 - 121	3	5
138 - 145	4	6
161 - 169	6	8
230 - 242	7	9
345 - 362	8	10
500 - 550	12 (see note 2) 15 (see note 3)	– –

NOTES:

(1) The values listed are the per string numbers. A vee string requires the given number in each string.

(2) This number can only be used when a 41 inch portable protective gap is in place.

(3) This number is based on known transient over-voltages for the COTP. (Applicable only to COTP).

(4) The minimum number of good insulator units is zero for deenergized and ungrounded circuits after a study has been performed to determine the voltage level on the line and that there is sufficient insulation to perform the work method safely. Minimum approach distances for the voltage of the circuit being worked shall be maintained.

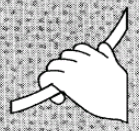
c. Maintain the minimum approach distances listed in Appendix A, Table A-1 in addition to the above restrictions. Also, electrically test each polimer replacement insulator before it is installed and discard defective units.

d. Visually inspect polymer fiberglass insulator assemblies for carbon tracking on the skirts. If tracking is found, the circuit is to be deenergized before work is done. Assemblies with visible damage are to be worked deenergized.

SECTION 14

Live-line Barehand Work

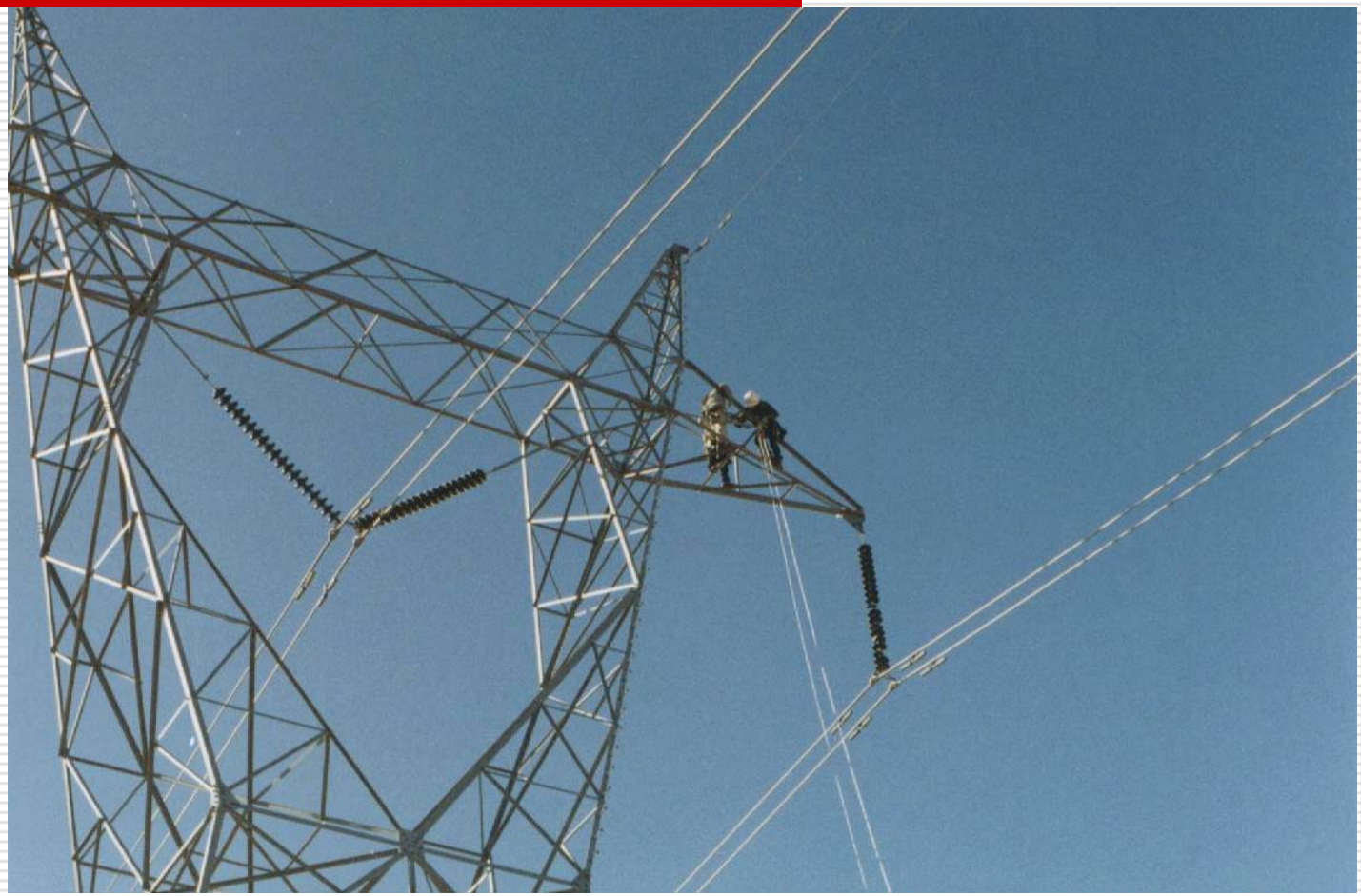
14.1 General
14.2 Barehand Techniques
14.3 Insulated Aerial Devices (Vehicle-Mounted)
14.4 Insulated Hook Ladders



Tail-gate Planning Meeting

Dedicated Observer.

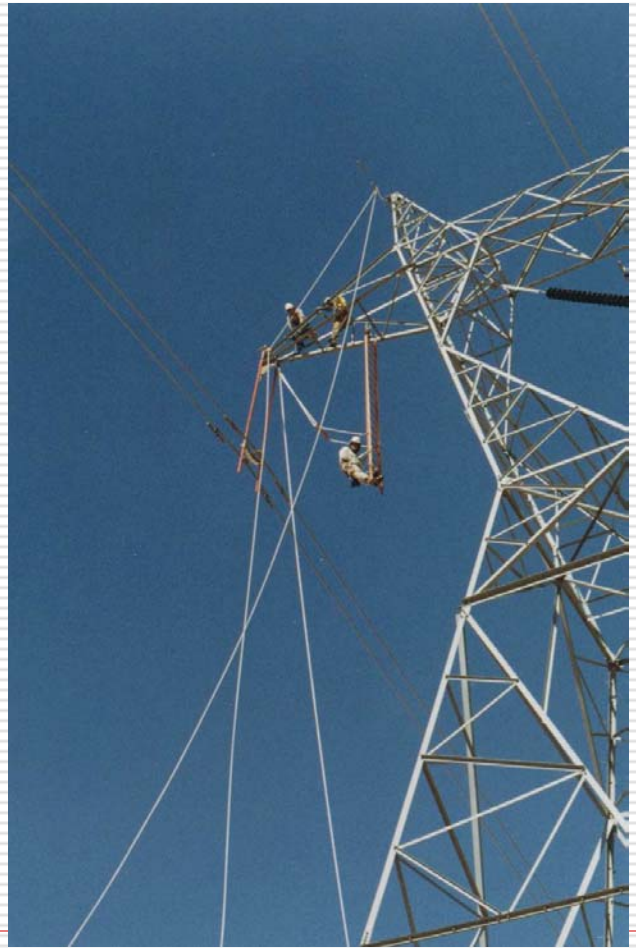
Work Preparations



Testing Insulators.

Check ladder for leakage current

Doing the Work



Applying Marker Balls.

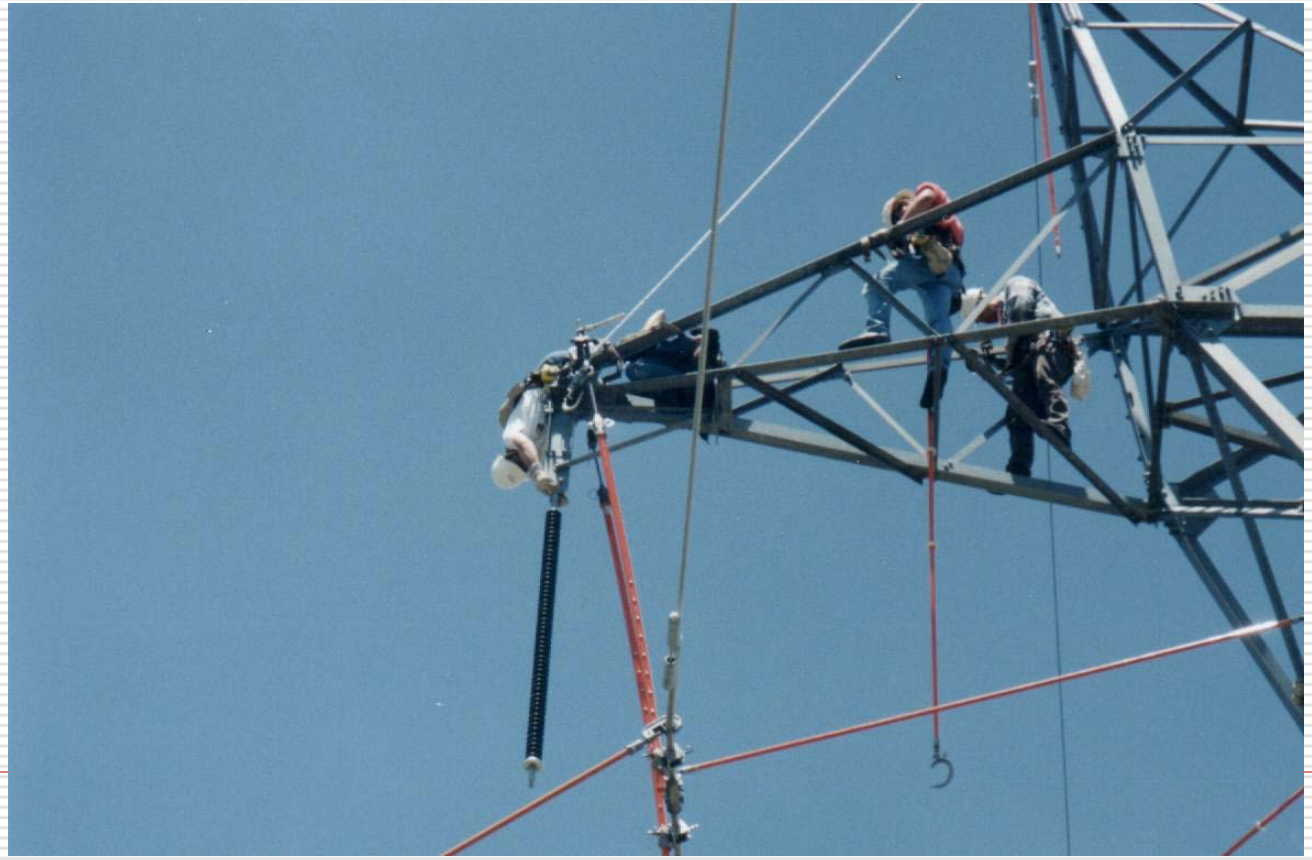
Applying Marker Balls

Changing Cross-arms Hot.

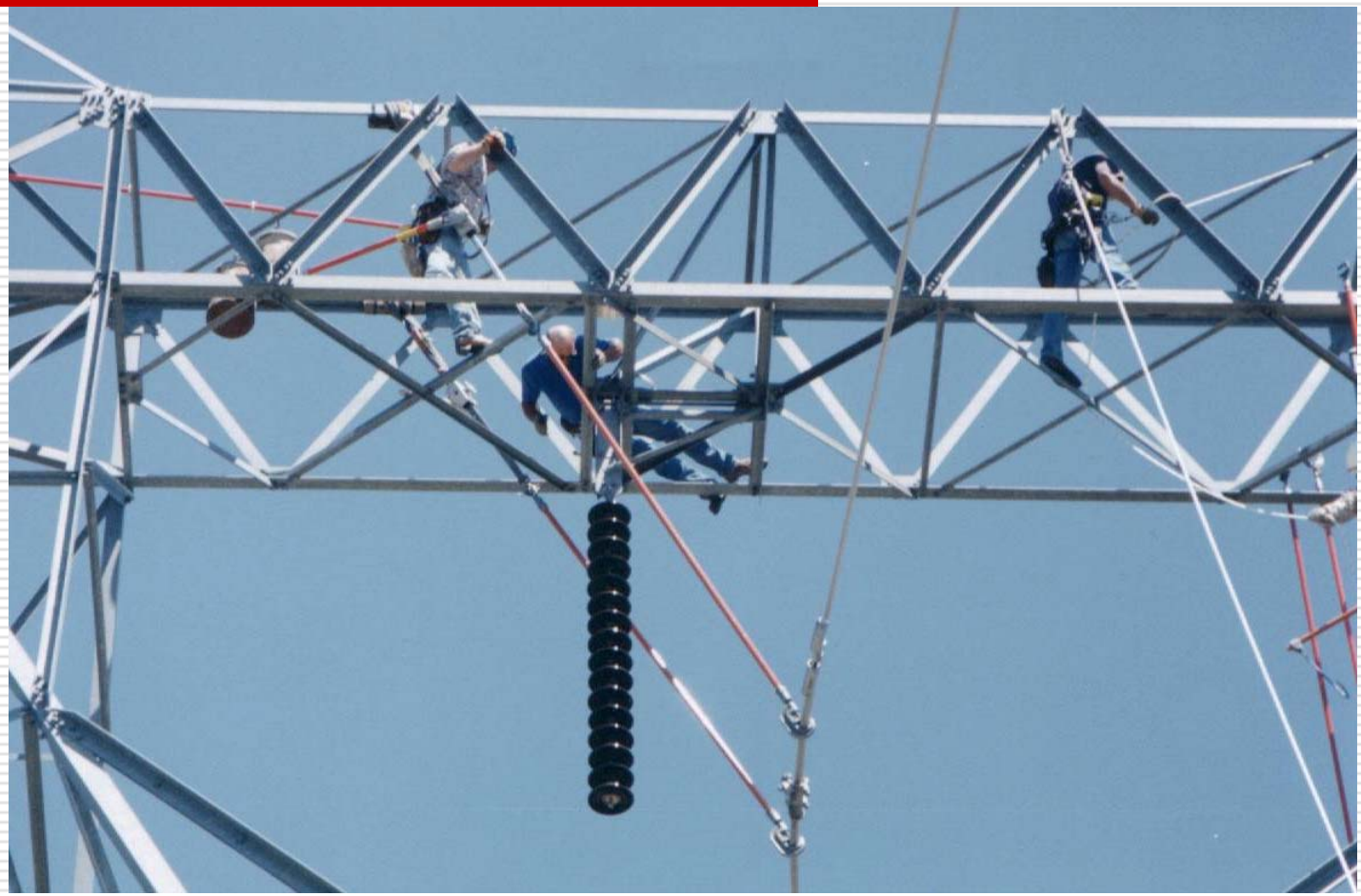
Most common Hot-stick procedure.

What a stretch!

Hey - sit on my legs so I don’t fall off!



Hanging out



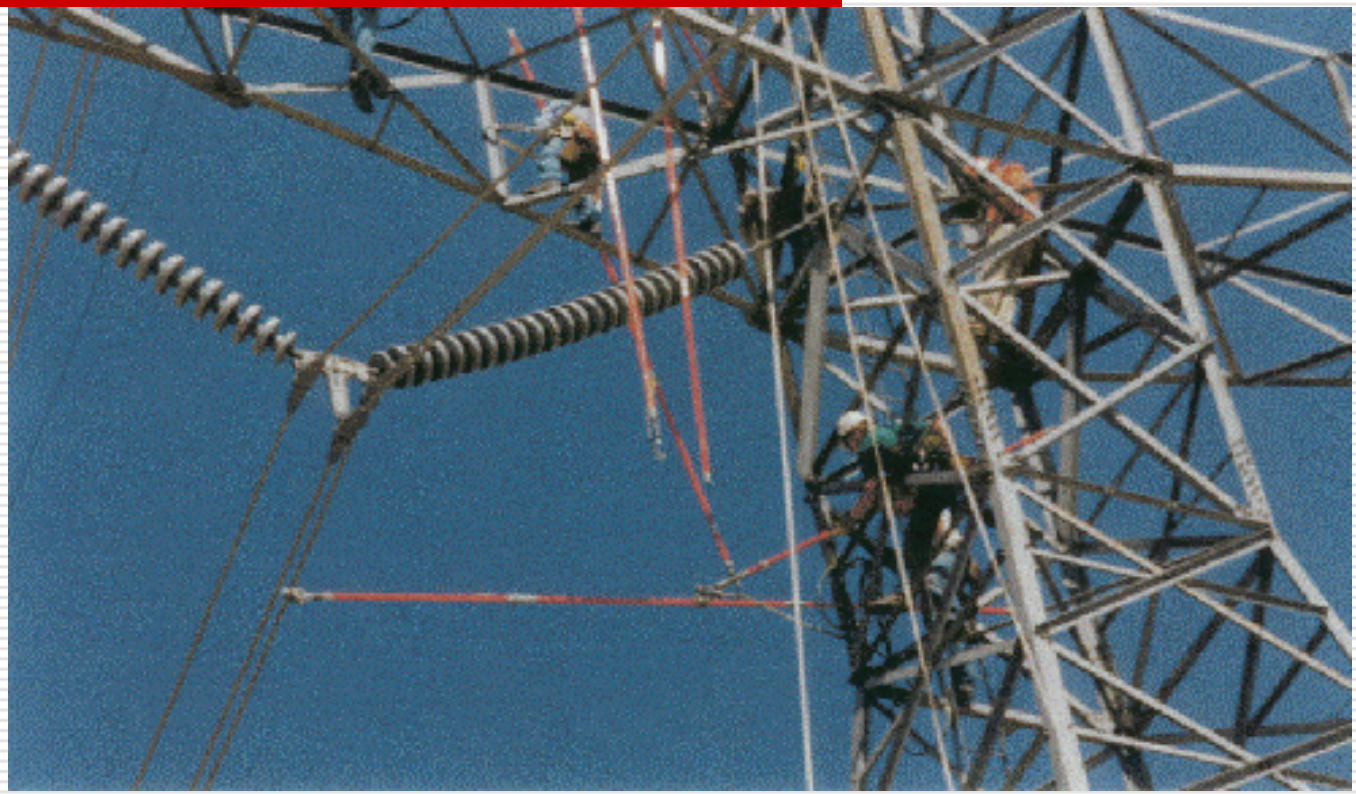
Arm Replacement on Radial 69K

Radial 69KV Line

Portable Protective Air Gaps

- PPAG's were first introduced in the Northeast to control overvoltages at the work site.
- PPAG's provide the best work site overvoltage control available to date.
- PPAG's allow live work to be performed with reduced minimum approach distances.

Western and the PPAG



Western and the PPAG

- Western upgraded a 230KV double circuit line to a 500KV single circuit line.
  - This design did not allow for live work procedures to be performed.
- Western elected to use the PPAG to allow for live working on the 500KV line which reduced the safe working clearances.

Western and the PPAG

- Western participated in an EPRI project to coordinate the PPAG with the compact design and to develop live working procedures.

De-energized Working Issues

- Beware of the grounding trap.
- Takes time to ground.
- Once again you can’t always get the line de-energized.
- Safer?
  - More people seem to get hurt on lines they assume were de-energized, than on a known energized line.

Advantage of De-energized

- De-energized work may be quicker for more difficult work.
  - Pole or structure replacement.
  - On going projects lasting more then one day
  - Multiple crews on one line section
  - Work can be accomplished with fewer people

Questions?

2004 DOE Electrical Safety Committee Meeting

Lessons Learned from Electrical Fatalities in Private Industry

Mike W. Bahr

Corporate Safety Director

2004 DOE Electrical Safety Committee Meeting
July 26-29, 2004

Las Vegas, Nevada

Lessons Learned from Electrical Fatalities in Private Industry

Mike W. Bahr

Corporate Safety Director

R.A. Waffensmith & Co., Inc.

WC Incident Count and Reserves

Severity Cost Range	August 2000-April 2004			
	Count	%	Reserves	%
$0-$2000	2809	68%	$1,314,042	2%
$2001-$10,000	569	14%	$2,875,165	4%
$10,00-$30,000	262	6%	$4,904,881	7%
$30,001-$75,000	236	6%	$11,277,638	16%
$75,001 & Greater	237	6%	$49,368,987	71%
Summary Total	4113	100%	$69,740,713	100%

WHY DO ACCIDENTS HAPPEN?

Accidents Happen for One or Both of the Following Reasons:

- Unsafe Acts
- Unsafe Conditions

UNSAFE ACTS

Unsafe Act:

- A behavioral departure from an accepted, normal, or correct procedure, or practice which, in the past, has produced injury or property damage or which has the potential to do so.

An unnecessary exposure to a hazard

- Horseplay, running
- Drug or alcohol use
- Not following procedures
- Taking chances
- Using damaged equipment
- Not using personal protective equipment

UNSAFE CONDITIONS

Unsafe Condition -

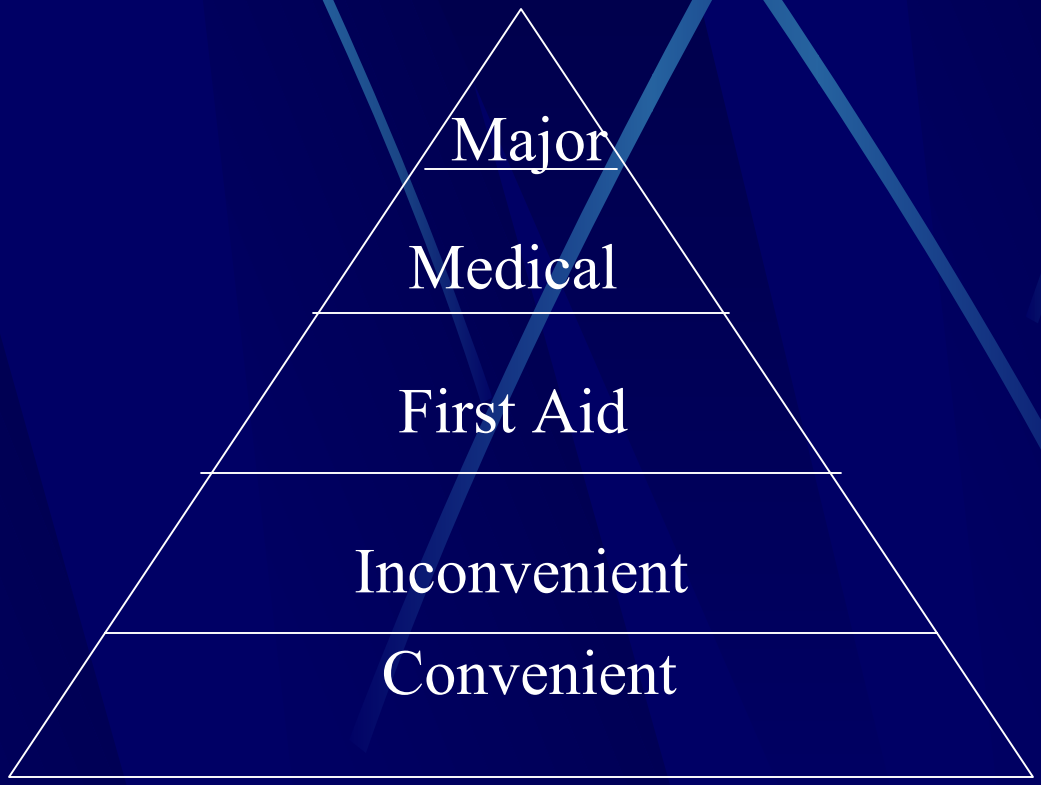
- Any physical state which deviates from that which is acceptable, normal, or correct in terms of its past production or potential future production of personal injury and or damage to property.

Examples

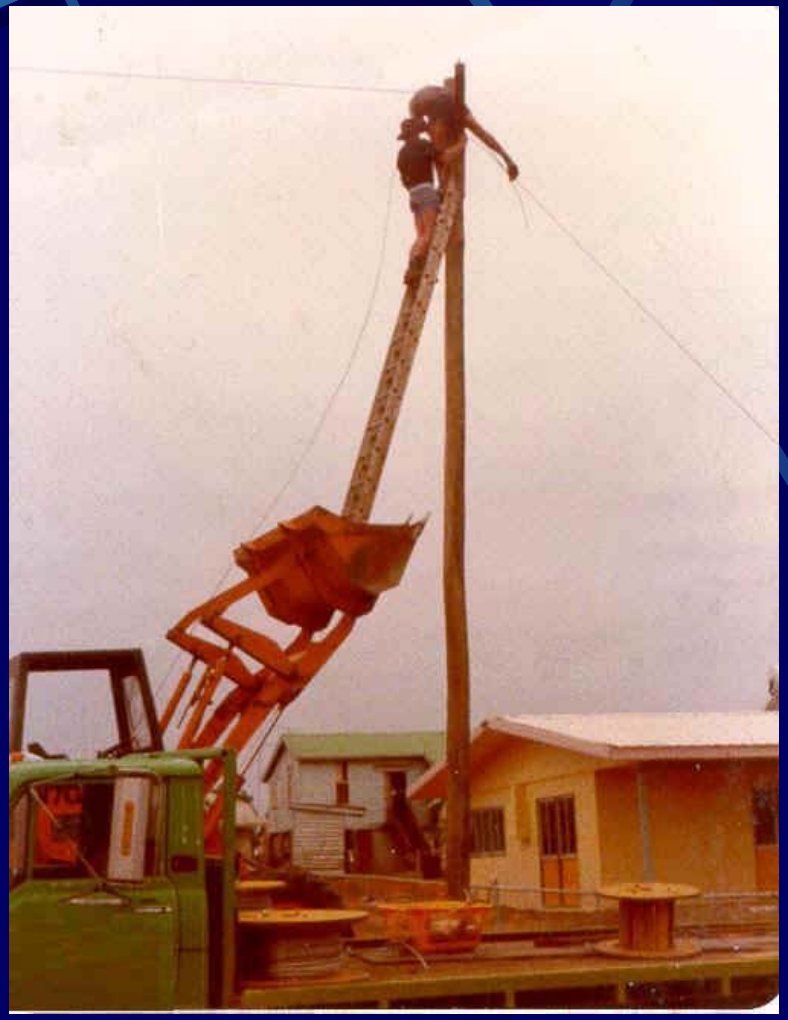
- Damaged equipment
- Poor Lighting
- Missing machine guards
- Unsafe atmosphere
- Lack of proper equipment
- Weather

UNSAFE CONDITIONS

“Shortcuts”



“Shortcuts”

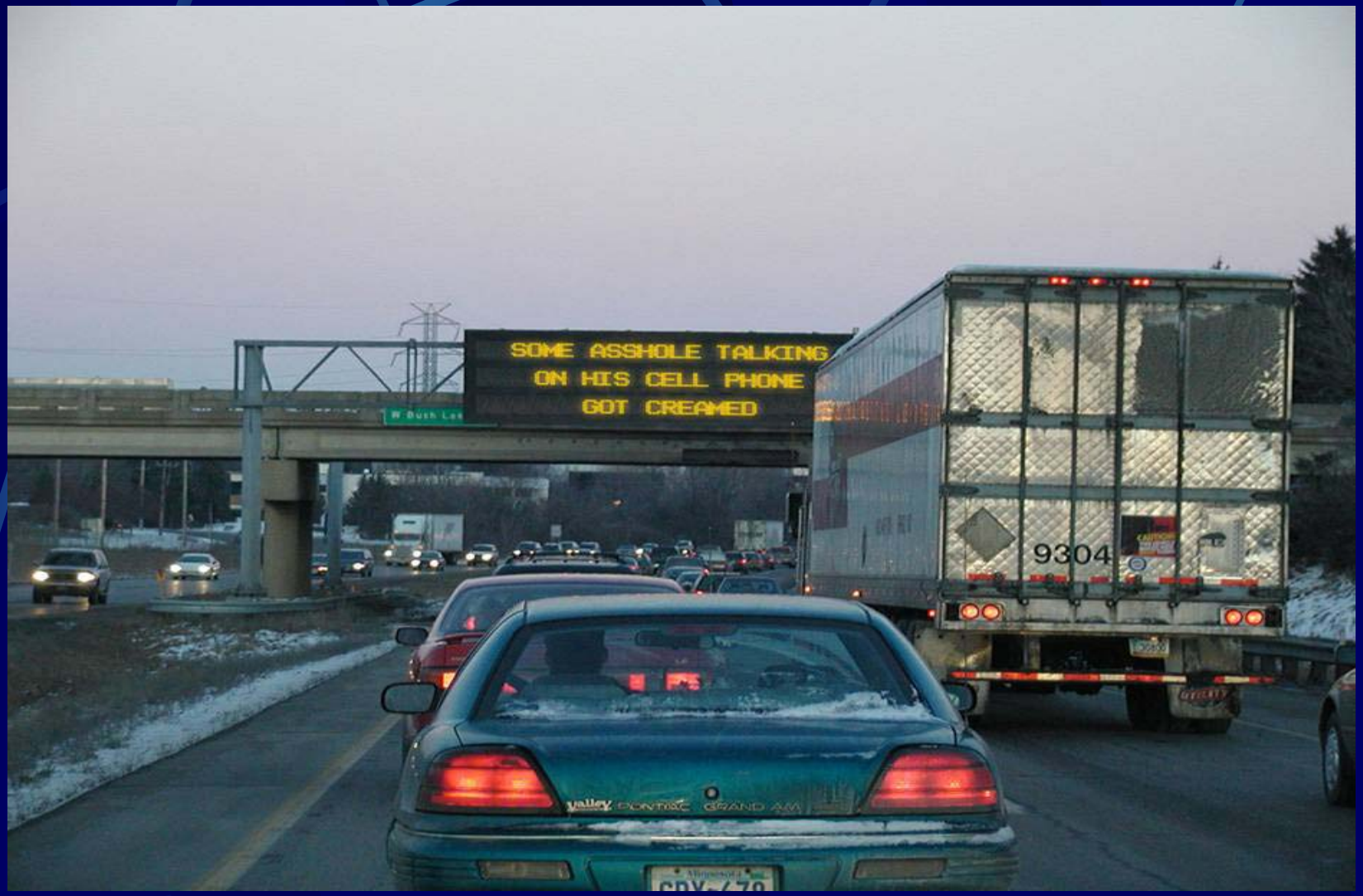


“Shortcuts”

“Shortcuts”

“Shortcuts”

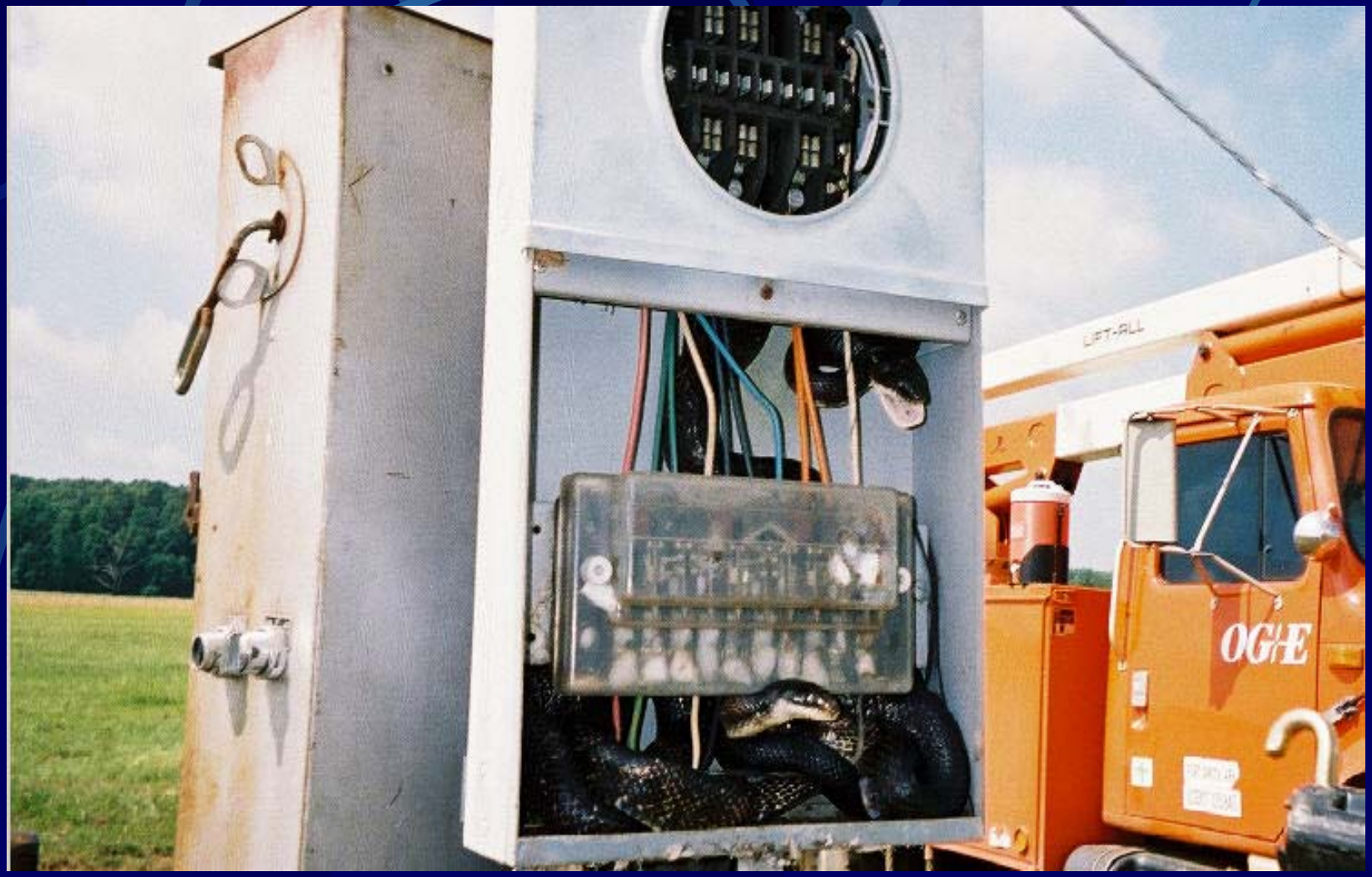
Paying Attention

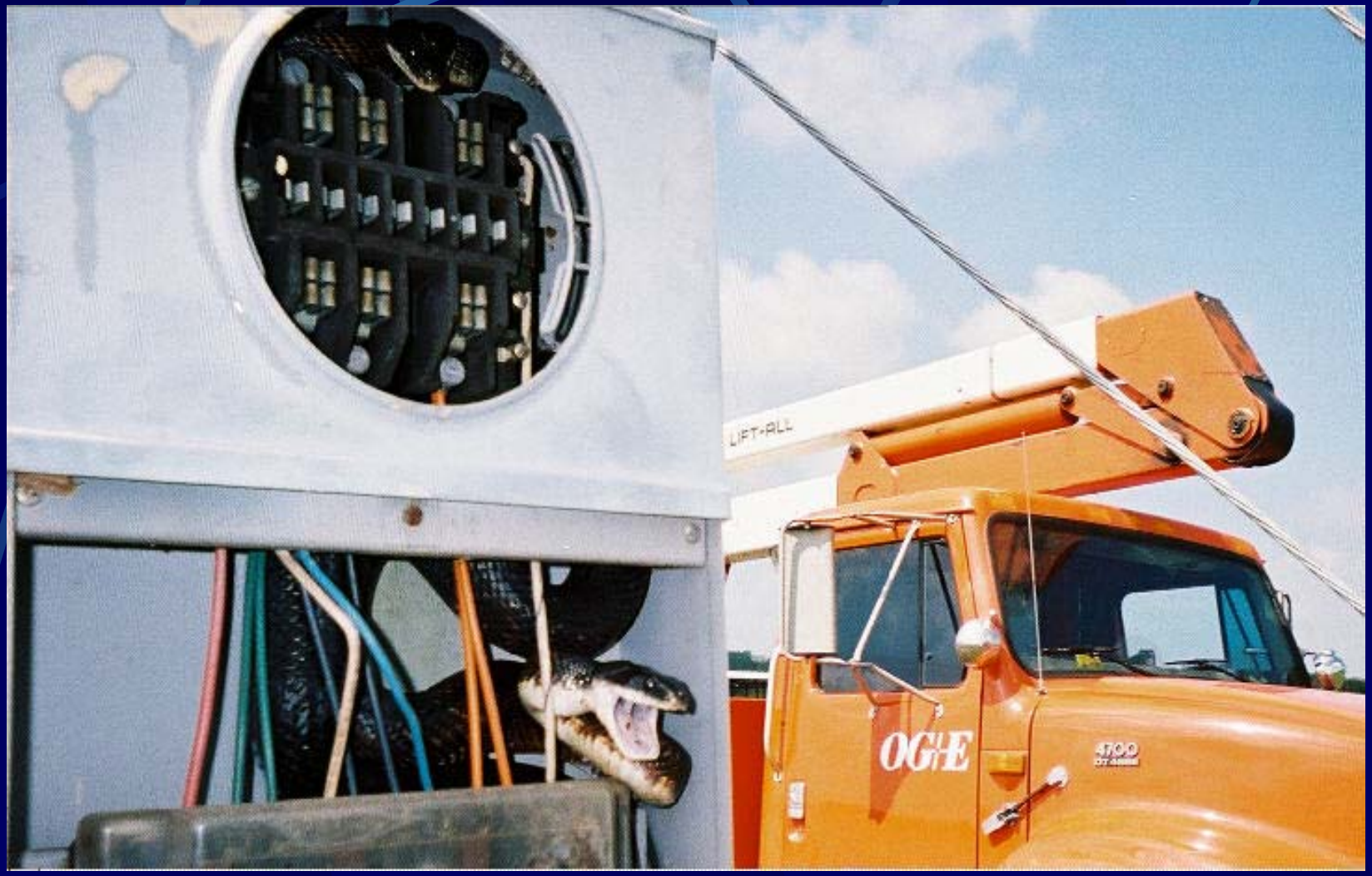


Driving To Fast On Ice

Electrical Contact

Not all Hazards are Electrical


LIFT-ALL
OGE


LIFT-ALL
OGE

OG&E

IMPACT OF ACCIDENTS

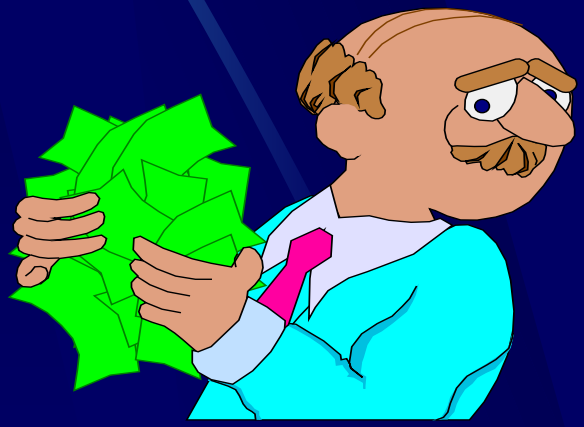
How do Accidents Affect:

- Your
  - Finances
  - Health
  - Career
- Your Family

IMPACT OF ACCIDENTS

Affects On The Company

- Project Delays - Missed Deadlines
- Increased insurance costs
- Costs of replacement employees, materials, tools, and equipment
- OSHA fines and penalties
- Loss of public image
- Not able to bid on projects
- Bankruptcy



IMPACT OF ACCIDENTS

Criminal Prosecution of Managers, Supervisors and Employees for Serious Accidents is Possible

IMPACT OF ACCIDENTS

Michigan Attorney General Granholm Files Charges In Construction Workers' Deaths

Report of House Committee on Government Operations

“ Getting Away with Murder in the Workplace: OSHA’s non-use of Criminal Penalties for Safety Violations.”

Conclusion / Recommendation

- Conclusion: “Inadequate use has been made of the criminal penalty provision of the Act.”
- Recommendation to Congress: “OSHA should take the position that the states have clear authority under the Federal OSH Act, as it is written, to prosecute employers for acts against their employees which constitute crimes under state law.”

Department of Justice

". . . As to whether the criminal penalty provisions of the OSH Act were intended to preempt criminal law enforcement in the workplace and preclude the states from enforcing against the employers the criminal laws of general application, such as murder, manslaughter, and assault, it is our view that no such general preemption was intended by Congress. . . .

Department of Justice cont.

"As a general matter, we see nothing in the OSH Act or its legislative history which indicates that Congress intended for the relatively limited criminal penalties provided by the Act to deprive employees of the protection provided by state criminal laws of general applicability."

Current State of Law

- OSHA preempts for civil matters.
- OSHA does NOT preempt for criminal matters.

Two Investigations

- This means that not only will OSHA investigate fatalities and multiple-injury cases, but that
- Police and Local Prosecutors may also investigate.

Recent Prosecutions

- Howard Elliot, owner of a South Dakota plumbing firm, pled guilty to criminal charges of willfully violating OSHA trenching safety standards after two of his employees were killed in a trench collapse. He received a six-month sentence (which was suspended to 45 days) and 3 years probation. Elliot also was ordered to pay restitution to the victims' families.

Recent Prosecutions

- KAZIMIERZ CHMIELEWSKI, the owner of Protech Construction Company, was cited by OSHA for several safety violations at an Illinois work site, including one willful violation. Chmielewski then twice offered $1,000 cash bribes to OSHA officials to get out of the $35,000 willful violation charge. In November 1998, he pled guilty to one count of bribery and was sentenced to six months in jail and six months home confinement.

Recent Prosecutions

- Employees of MIT Tank Wash, a tank cleaning company in Savannah, Ga., were required to clean fuel out of the tanks -- including a hazardous fuel additive, fleurodyne FD-100. Violating OSHA regulations, MIT's employees routinely cleaned tanks alone. One employee, who entered a tank alone, quickly became disoriented, and died from the toxic fumes. The company owner pled guilty to a willful violation of OSHA regulations, and was sentenced to six months in jail, one year probation, and a $190,000 fine.

Recent Prosecutions

- Smith and Dennis were the owners of South East Towers, a South Carolina communications tower company. One of their employees, John Christiansen, was killed in 1995 when he fell 150 feet while retrieving equipment from a tower in Jacksonville, Fla. According to OSHA, the two men tried to cover up the fact that Christiansen was not wearing the proper safety equipment when he fell. Smith and Dennis pled guilty to a willful violation in April 1997 and each was sentenced to three months in prison. The two men were also ordered to pay more than $7,300 restitution for Christiansen's funeral.

Recent Prosecutions

- Jeffrey Highfill, an employee of LeMaster Steel Erectors, fell more than 25 feet from the roof of a construction site in Mason, Ohio. Three years later, the firm pled guilty to willfully violating federal fall protection regulations, and two of its officials -- Company Safety Director Michael Onyon and Regional Manager Jay Holloman -- as well as site foreman Ronald Lee Creighton, pled guilty to making false statements to OSHA investigators. Hollomon and Onyon each were sentenced to six months in prison, three years probation, and fines of $2,000. Creighton was sentenced to four months in prison, three years probation, and $1,000 in fines. LeMaster Steel was fined $300,000, ordered to pay $3,500 in burial expenses, and placed on five years probation.

Recent Prosecutions

- The owner of an Illinois plumbing company, Marble pled guilty to charges that he lied to investigators regarding a 1999 trench collapse that killed employee Chad Sacker, who was buried under approximately 8 feet of soil. In an attempt to avoid liability, Marble obstructed OSHA's investigation by creating fake documents to cover up the incident. He was sentenced to five months in prison, five months home confinement, 2 years supervised release following the home confinement and a $3,000 fine.

Recent Prosecutions

- The owner of Evergreen Resources, a chemical processing and fertilizer company, was sentenced to 17 years in prison for knowingly exposing his employees to cyanide gas and making false statements to the government. The jury found Mr. Elias guilty of ordering his employees to clean a 25,000 gallon storage tank containing cyanide without taking the proper safety precautions. As a result, one employee collapsed in the tank and suffered permanent brain damage. Because of the injury, Mr. Elias was also ordered to pay nearly $6 million in restitution to the victim and his family.

Recent Prosecutions

- Labor Secretary Elaine L. Chao, stated: While we continue our efforts to assist employers … we will not hesitate to use the full range of enforcement tools, including referral … to … Justice for criminal prosecution. Compliance …would have saved lives. Today's joint effort … indicates the Administration's strong resolve to enforce workplace safety and health regulations with no tolerance for employers who willfully disregard their obligations under the law."

DIRECT – INDIRECT COSTS

SALES REQUIRED TO PAY FOR AN ACCIDENT

Total Cost of Accident	1%	2%	5%	10%	15%
$ 1,000	$100,000	$ 50,000	$ 20,000	$ 10,000	$ 6,666
$ 5,000	$500,000	$250,000	$100,000	$50,000	$33,333
$10,000	$1,000,000	$500,000	$200,000	$100,000	$66,667
$25,000	$2,500,000	$1,250,000	$500,000	$250,000	$166,667
$100,000	$10,000,000	$5,000,000	$2,000,000	$1,000,000	$666,667

VIOLATIONS

Other Than Serious

- Would not cause death/serious physical harm

Serious

- Substantial probability that death/serious harm could result

Willful

- Intentionally and knowingly committed

VIOLATIONS

Repeat Violations

- Issued when a citation has previously been issued for similar condition
- Usually the same standard
- Prior citation can have been anywhere in the prior three years- not just the same jobsite!

PENALTIES

Type of Violation	Minimum Penalty per Violation	Maximum Penalty per Violation
Other Than Serious		$ 7,000.
Serious	$ 100.	$ 7,000.
Willful	$ 5,000.	$ 70,000.
Willful with Fatality (1st conviction)		$250,000/500,000 or 6 months in prison or both
Willful with Fatality (2nd conviction)		$250,000/500,000 or 1 year in prison or both
Repeated	$ 5,000.	$ 70,000.

"EXCUSES"

Don't let these "Excuses" be the cause of an accident!

- That's the way I always do it…
- I can take shortcuts, I'm experienced…
- I was just trying to fix it…
- I thought I knew how….
- I was in a hurry
- Doing it safely takes too much time…
- I didn't know it was loaded...

How Do We Reduce and Prevent Accidents?

- Management Commitment and Employee Involvement
- Training and Education
- Identification and Control of Hazards
- Accountability & Enforcement

Management Commitment and Leadership

- Policy statement: goals established, issued, and communicated to employees.
- Participation in safety meetings, inspections; agenda items in meetings.
- Commitment of resources is adequate.
- Safety rules and procedures incorporated into site operations.
- Management observes and enforces safety rules.

SAFETY RESPONSIBILITIES OF MANAGERS

Managers have a primary responsibility for the safety and well being of all employees who are under their control. The manager impacts the overall safety program by:

- Establishing general safety procedures
- Monitoring those procedures to insure compliance
- Providing support and training, setting examples and
- Holding other management personnel accountable for accident prevention

SAFETY RESPONSIBILITIES OF SUPERVISORS

Supervisors are responsible for establishing a positive safety attitude among those employees reporting to them. They are responsible for reviewing the safety performance of their foreman, crew leader and employees, and bring about positive change when necessary.

SAFETY RESPONSIBILITIES OF THE FOREMAN/CREW LEADER

A foreman or crew leader must believe in safety, insist on safety, and practice safety in order to measure up to the company's standard of a good foreman or crew leader. Enlarge measure, the success of the company's safety program depends on the efficiency of the foreman or crew leader. While being responsible for the production activities of subordinates, the foreman or crew leader is also responsible for their safety, and in **no case are unsafe methods or practices to be used in the apparent interest of greater production.**

SAFETY RESPONSIBILITIES OF EMPLOYEES

Each employee is required, as a condition of employment, to follow safety practices for personal protection, protection of fellow workers and protection of the public.

Each employee is expected to accept safety as a personal matter and to cooperate in the safety program by developing safe work habits, and by reporting to the crew leader hazardous working conditions, unsafe practices, and unsafe apparatus.

Training and Education

Training is the key to success in managing safety in the work environment. Attitude is also a key factor in maintaining a safe workplace. Safety is, and always will be a team effort, safety starts with each individual employee and concludes with everyone leaving at the end of the day to rejoin their families.

Identification and Control of Hazards

- Periodic site safety inspection program involves supervisors
- Preventative controls in place (PPE, maintenance, engineering controls)
- Action taken to address hazards
- Safety committee, where appropriate

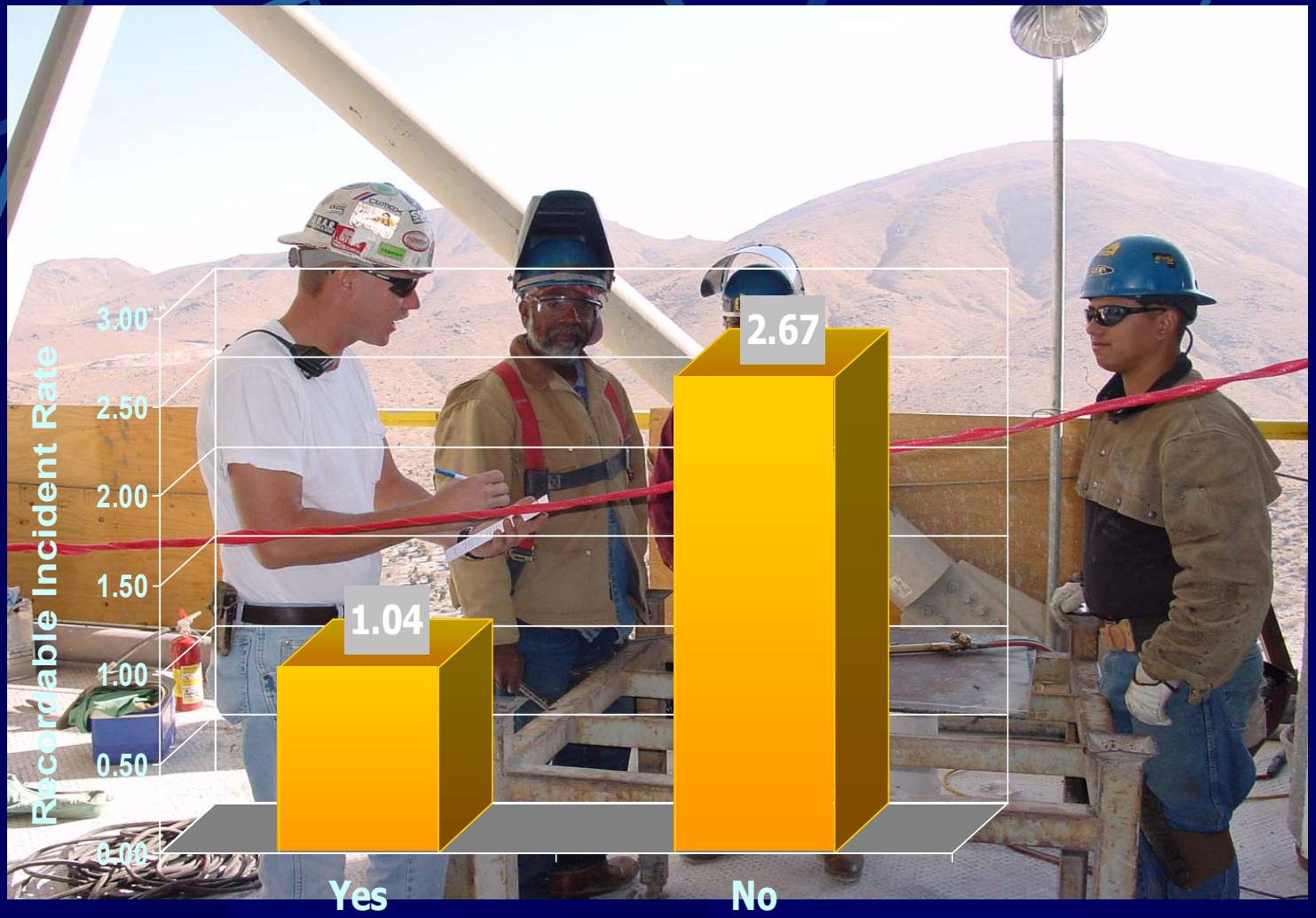
Accountability & Enforcement

- Periodic site safety inspection program involves supervisors
- Preventative controls in place (PPE, maintenance, engineering controls)
- Action taken to address hazards
- Safety committee, where appropriate

(c) Job Briefing

- Subjects:
  - Hazards and personal protective equipment
  - Work procedures and special precautions
  - Energy source control
- Number of briefings:
  - Before start of each day or shift
  - Additional briefings for changes
  - Based on the nature and complexity of work

Job Briefing



Job Briefing

GENERAL FOREMAN SAFETY CHECK LIST

North Houston Pole Line Corp.

Crew Foreman _____ Date _____ Time _____

Location _____

	Check One Yes	No
1. Was a Work Conference held prior to any work?	_____	_____
2. Was every man present at the conference?	_____	_____
3. Was an explanation given as to how the job was to be worked?	_____	_____
4. Were hazards pointed out?	_____	_____
5. Practices involved	_____	_____
a. Working on or near energized conductors or equipment?	_____	_____
b. New construction - Dead Work?	_____	_____
c. Working between grounds?	_____	_____
6. This Work requires	_____	_____
a. Wearing rubber gloves?	_____	_____
b. Covering primary conductors?	_____	_____
c. Covering secondary conductors?	_____	_____
d. Use of hot sticks?	_____	_____
e. Securing of work tag?	_____	_____
f. Were Safety signs & cones displayed properly?	_____	_____

7. Remarks and Reprimands _____

_____

_____

_____

_____

8. Meeting Conducted By: _____

General Foreman

Job Briefing

Daily Job Task Analysis

Company Name:		**Date:**
Time:	**City:**	**State:**
Job#:	**Jobsite:**	

PPE Required	Yes	N/A
Hardhat		
Safety Glasses/Goggles		
Ear Protection		
Leather Gloves		
Boots/Foot Protection		
Face Shield		
Welding Hood		
Chemical Rubber Gloves		
Dielectric Gloves (Tested)		
Protective Sleeves		
Air Test (Electrical PPE)		
Reflective Vest		
Respirators		
Fire Extinguisher		
Fall Protection		
Competent Person		
Guardrails		
Safety Nets		
Full Body Harness/Lanyard		
Positioning Device		
Warning Line		
Safety Monitor		
Barricaded/Control Zone		
Falling Object Protection		
Daily Inspections		
Aerial Lifts		
Qualified Operator		
Daily Inspection		
Grounded or Barricaded		
Warning Labels		
Controls Labeled		
Fall Protection		
Dielectric Tests		
Ladders		
Daily Inspection		
Warn../Usage Labels Affix.		
3 Feet Above Landing		
Ladder Secured		

Confined Space	Yes	N/A
Competent Person		
Permitted/Non-Permitted		
Atmosphere Monitor		
Traffic Control		
Hole Watch		
Man Hole Guard		
Forced Ventilation		
Rescue Equipment		
Resc. Team/Serv. Identified		
Hot Work Permit		
Warning Signs		
Written Program on Hand		
Contractors Notified		
Confined Space Log Book		
Excavations		
Competent Person		
Utilities Located		
Integrity of Adj. Structures		
Soil Classification		
Location of Spoil Bank		
Overhead Load Protect.		
Water in Trench		
Ladders/Ramps (Circle 1)		
Ladders Secured		
Sloping/Benching		
Shoring System		
Tabulated Data		
Atmosphere Tested		
Daily/Periodic Inspection		
Warning System		
Emergency/Rescue Equip.		
Log Book		
Backhoe and/or Trencher		
Certified Operator		
Pre-Operation Inspection		
Required Maintenance		
All Fluids Checked		
Chain Adjustment		
Tire Pressure/Lug Nuts		
Check Loose Fasteners		
Anti-Theft Switch		
Grease Stingers & Buckets		

Additional Hazards Identified & Discussed:

Traffic Control	Yes	N/A
Traffic Control Plan		
Right/Left Lane Closed		
Flagman Ahead		
Road Construction Ahead		
Arrow Board		
Message Board		
Traffic Control Zone		
Advance Warning Area		
Transition Area		
Buffer Space		
Work Area		
Termination Area		
Barricades/Cones		
Stop/Slow Paddles		
Cranes/Digger Derricks		
Competent Person		
Annual Inspection		
Daily Inspections		
Fire Extinguisher		
Signal Person		
Outrigger Pads		
Rigging Equip. Inspected		
Wind Sock		
Warning Signal/Light		
Load Charts		
Protec. from Susp. Loads		
Dielectric Tests		
Medical		
Person Trained CPR/FA		
First Aid Kit		
Bloodborne Pathogen Kit		
Occupation Med List		
Hospital Location		
Administrative Issues		
OSHA Poster		
MSDS Manual		
Written Safety Program		
Permits		
Logs		

Electrical	Yes	N/A
Daily Inspec. Tools, Cords		
GFCI/Assured Grounding		
Hot Work-Author. Person		
Survey of Daily Conditions		
Operating Voltage		
Elevated Structures Inspec.		
Minimum Safe Distances		
Energized/Deenergized		
Grounding Equipment		
Lockout/Tagout		
Competent Person		
Lockout Procedure		
Voltage Meter		
Grounding Equipment		
Electrical Flow Tester		
Directional Drilling		
Insulated Boots		
Insulated Gloves		
Location of Utilities Verified		
Locate Sketch on Site		
Strike Sensor Grounded & Tested		
Strike Procedures Discussed		
Equipment Grounded		

Daily Incident Report

Disciplinary Problem

Accident/Incident/Injury

Power Lines

Power Company notified when work is conducted near ANY electrical source.

Yes ☐
N/A

Person-in-Charge:

Crew Members:

Safety Dept. Review:

Date:

Job Briefing

JOB TASK ANALYSIS REPORT

Dillard Smith Construction Company

FOREMAN: _____

DATE: _____

JOB LOCATION: _____

BRIEF JOB DESCRIPTION:
_____
_____
_____
_____

EQUIPMENT USED:
_____
_____
_____
_____

___OVERHEAD
___UNDERGROUND
___SUBSTATION ___OTHER

WORK PROCEDURES INVOLVED:
___Energized
___De-Energized
___Primary-Voltage: _____
___ Secondary -Voltage:_____
___ Trnsmsn -Voltage: _____
___ Single phase Transformer(s)
___ Transformer Bank(s)
___ New Construction
___ Rebuild
___ Tree Trimming
___ Enclosed/Confined Space
___ Excavation/Trenching
___ Traffic Control
___ Climbing
___ Other (Describe):
_____

ENERGY SOURCE CONTROL:
___ Lockout/Tagout
___ Line De-energization
___ Test for Voltage
___ Capacitor Discharge
___ Install Protective Grounds

LIST ANY 'NEAR MISSES' OR FIRST AID CASES
_____
_____
_____
_____
_____

SPECIAL PRECAUTIONS:
___Inspect Jobsite for Hazards
___Inspect Critical Safety Equip.
___Test/Monitor Atmosphere
___Job Requires Attendant/Obsvr
___Equipment Grounded

ASSOCIATED HAZARDS:
___Electrocution
___Backfeed
___Falls
___Chemical Hazards
___Dog/Animal Bites
___Hazardous Atmosphere
___Engulfment/Cave-in
___High Noise Levels
___Heavy Equipment
___Moving Machinery
___Temperature Extremes
___Water
___Fire/Explosion
___High Speed/Volume Traffic
___Other (List:_____)

PERSONAL PROTECTIVE EQUIPMENT REQUIRED:
___ Head Protection
___ Protective Footwear
___ Eye/Face Protection
___ Protective Clothing
___ Respirator
___ Fall Protection
___ Rubber Gloves
___ Safety Vest
___ Leather Gloves
___ Hearing Protection
___ Other (List):
_____
___ Other (List):
_____

EMPLOYEES ATTENDING:
(Sign Individually):
Foreman/Supervisor:
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

4001 Industry Drive
Chattanooga, TN 37416
Phone: 423-894-4336
Fax: 423-490-2215

WORK AT WORKING SAFE

"And the end is that the workman shall live to enjoy the fruit of his labor; that his mother shall have the comfort of his arm in her age; that his wife shall not be an untimely widow; that his children shall have a father, and that cripples and hopeless wrecks who were once strong men shall no longer be a by-product of industry."

1 Reason for Working Safe

THE THEORY OF CABLE LOCATION

Locating Different Techniques

Training is the most important aspect of cable location. Understanding what your equipment can and can not do is the most important part of Training locating. In addition to understanding your equipment, being able to obtain information about all the buried utility lines located in the area is of the utmost importance. All drawings, plans, and any other information should always be obtained and used and, if found to be faulty, corrected as soon as possible.

There are a number of techniques that can and are being used to identify underground cables as well as pipes.

Pray

Pray that where someone is digging is not where your conductor is located. This method causes an unknown number of dig-ins as we all do not have the close relationship required for this type of location of cables. This method is reserved for fiber optic cables with no metallic content or tracertape.

Downward Looking Radar (GPR)

While very useful in many applications, the size, expense, and level of expertise required put this equipment beyond the range of usefulness for the everyday location work. There is a lot of research and development going on with this method and great progress is being made. The ability to see non-metallic as well as metallic objects is of great worth to the location industry. One of the serious drawbacks of this equipment is different soils and the expertise required to interpret the readings.

Sonic Surveying

This requires placing a sound, or in some cases an ultra-sonic, wave on the conductor to be located and listening along the line for the vibration above the conductor. While sounding very feasible, this method only works on pipe and for a very limited distance. This method in its current form has been known to cause damage to the conductor by the vibrations set up in the pipe. There are several projects going at present to improve this method and make it work on all underground conductors, not just pipe as it does at present.

Dowsing

This technique is the oldest form of cable locating, and locators are still being sold and research being done at the university level on this method. Everyone has a different

theory and idea as to the methods used. Not at all based in technology, this method has been known to work when all other methods have failed.

Electromagnetic Location

This method of cable location is at present the most accepted method. The main shortcoming is that the line to be located must have a metallic content or tracer wire installed in order to be located. This technology has a large advantage over the other methods of locating and will be explained in depth in the following pages.

Advantages of Electromagnetic Location for Cables

1. Cost effective
2. Easy to use with proper training
3. Accurate
4. Provides sweeping of entire rapidly
5. Rugged
6. Proven technology
7. Provides depth automatically or with triangulation
8. Equipment is portable
9. Works in all soil conditions and paving
10. Accepted industry wide as the best available method

Basic Location Electromagnetic Theory

As a current flow is created on any conductor, a magnetic field is created. This magnetic field, in theory, forms a cylindrical shape around the conductor. This magnetic field created by the current flow is produced by the current flowing and not the presence of voltage.

The shape of this field is not altered by insulation or in location by different types of soil. If a DC current is placed on the conductor, the field is of constant magnitude and direction much as the permanent magnet of the earth's magnetic field. In order to measure this type of field, an instrument capable of measuring both signal strength and polarity is required. This becomes very difficult due to the difficulty of measuring a static field against the earth's existing magnetic field.

With AC or pulsating DC current created on the conductor, a magnetic field is created along with an oscillating frequency and reversals in the case of AC and oscillating frequency alone in the case of DC current flow. It is this oscillating frequency which makes it possible to locate the conductor which radiates the signal created by the oscillating of the signal.

The rate of change of the alternating current flow is the frequency, which is the number of pulsations or cycles per second now known as Hertz and shown as HZ. KHZ is the measurement of HZ in thousands of Hertz, while MHZ is the measurement of HZ in

millions. Location frequency is measured in Hertz for audio frequency units and MHZ for those units in the radio frequency range.

Capacitance, Grounding, Frequency and Locating

Where there is direct electrical contact between the conductor and ground, there exist signal coupling. When the ground conductivity is low, coupling will be reduced; but when the ground conductivity is high, the coupling will be increased. This is not due to the fact that the higher soil resistance reduces the current flow, but the capacitance effect is reduced. One side of the circuit creating the capacitor is a good conductor and the other side is a poor conductor. This creates a circuit that stores a lower charge than a circuit with lower resistance. A much higher charge can be stored when the soil resistance is low. The conductivity of a point of contact between the conductor and ground is not affected by the frequency; there is a change in the effective impedance with changes in capacitance. Impedance of the line to signal is a combination of resistance and capacitance (as well as the inductive component that can be ignored due to the small effect that it has).

With impedance being such a factor in the quality of the location signal, it is important at the lower frequencies to have a transmitter that does an excellent job of impedance matching or tuning to the conductor circuit being located. Due to impedance, it is always easier to couple a higher frequency signal to a conductor than a lower frequency signal. The higher a frequency, the easier it leaks off the line due to capacitance into the ground return circuit. This signal leakage will also increase with line size. The lower frequency signals will have far less leakage due to capacitance than the higher frequency signals, which will result in the lower frequencies going farther and not being present on other conductors. It can be seen from these two variables that it is not possible to predict how far a signal will travel on a conductor or how much signal will flow on the conductor.

There is an optimum frequency for every conductor due to the effects of ground, capacitance, and resistance. The optimum frequency is the lowest frequency at which the location can be performed. Higher frequencies will have more signal lost due to capacitance coupling and will be subject to coupling by mutual induction than lower frequencies. In congested areas, using high frequencies will make it much more difficult to locate a single conductor.

Earth Return Current and AC Circuits

It is understood that an electric circuit must be completed in order for current to flow and that there must be current flow in order to generate the magnetic field required for location. The question is asked, “How can a low powered signal source (the locator transmitter) make a detectable current flow in a buried conductor that may or may not be insulated?” The voltage put out by the locator transmitter is not high enough to punch through the insulation to create a return signal path. The return signal path is created by the effect of capacitance on the AC or pulsating DC circuit. A capacitor is thought of as requiring two conductors, but there is only one conductor for the signal to travel on. What

is the other conductor required to complete the circuit to have current flow? While each particle of dirt has a high resistance per piece, there is so much of it that the earth acts as if there is a conductor layer completely around the conductor. These earth particles create a conducting layer around the conductor and the conductor charges up relative to the ground. The buried conductor acts as if it has a bunch or string of small capacitors along it.

When our AC or pulsating DC signal is applied to the conductor at an access point, current will flow out both ways and will decrease in magnitude as, due to distance, more and more leaks away due to earth coupling. The higher the frequency, the higher the current; and the higher the capacitance of the conductor and signal strength, the faster the loss of the signal back to the earth to return to the source. Capacitance increases with the area of the conductor; the size of the conductor affects the distance the signal will travel. The same signal (frequency, power and matching) will leak back to ground over a much shorter distance from a large conductor than from a small conductor. A conductor so small in diameter that little or no current flow will result will be very hard to detect, and with shielding will be almost impossible. The effect of capacitance coupling explains why signals decrease on a conductor and may disappear before the end of a cable or the next ground. Capacitance does make it possible to trace conductors that do not have a ground at the far end, as a sub out.

The ability of the ground to carry current will vary widely with local ground conditions. Wet soil is a much better conductor than dry sandy soil, and the resulting capacitance effects will vary greatly with the conductivity of the conductor. When the soil has a high conductivity, it becomes easier to induce current flow and the signal in the conductor is high due to a good return path. While the high conductivity produces a good signal, the easy return results in a shorter trace due to the signal being lost by capacitance in a shorter length. Low ground conductivity requires more energy to produce a signal on the conductor, but will be detectable along a greater length of the conductor. If the conductor is in direct contact with the earth, as a bare pipe or bare ground wire, the signal will leak away even more rapidly due to direct conduction.

Getting the Signal on the Conductor

The alternating flux is constantly changing as generated by the transmitter; and in order to be useful, it must be transferred to the conductor to be located. The signal on the conductor is imposed in three ways:

1. An antenna located in the signal transmitter is fed with the output of the transmitter, which becomes a broadcast antenna and sets up a magnetic field into the area. A conductor lying parallel to the coil is linked by this field and a voltage induced into the conductor. This method is the induction method of applying the signal. The signal current induced into the conductor will depend on how well grounded the line is, on what frequency is used, and if there are insulated joints, such as those on insulated pipe systems. A frequency of 8 KHZ or higher will be found to work effectively for induction. The higher frequencies will induce more easily, and the power of the lower

frequency will be all-important on an inductive locate. With the higher frequencies the more easily, the signal will be coupled to or induced on other adjacent lines. Where there is more than one line present, the one with the best grounding will generally carry the strongest signal. While sometimes induction is the only way to apply a signal to a conductor, it should be avoided when direct hook up can be made. The problem with induction is that the signal is in control of its path and all underground structures are not known. Lines may be adjacent to the conductor and more than one line will receive the signal. With the use of induction, it is not possible to be certain about the identity of the line to which the signal is applied, and the signal strength will not be as strong as when applied with one of the direct methods.

2. Direct connection of the output from the transmitter to the conductor is accomplished by connecting one of the output leads to an access point on the conductor and completing the circuit by creating a ground return path by placing a stake or plate into the ground. The signal that travels this path will be detectable along the conductor dependent upon the type and size of the conductor, soil conditions, power output, frequency used and other factors. The presence of insulated pipe joints missing ground bonds will reduce the signal. Any lines sharing a common ground point with the connected line will also carry a signal to a greater or lesser extent, depending on how well the ground coupling is on these connectors.

3. Using the clamp uses the induction principle and gives a similar result to direct connection, but without requiring electrical contact to the conductor. The output from the transmitter is effectively coupled to the conductor by clamping around the conductor with a split torodial magnetic core, which carries a primary winding and induces a signal upon the conductor to be traced. The conductor becomes the secondary winding of a transformer and will have a strong signal provided that a good coupling to ground exist on both ends of the conductor with the clamp around it.

   Clamping has all the advantages of the direct connection method. While not having as strong a signal on the conductor, the need for a good electrical contact with the conductor, as well as a driven ground, is avoided. Any conductor sharing a common connection will divide the signal current between them, and the strongest signal will be on the conductor clamped on.

Frequency Selection

The choice of frequency is an important factor for effective tracing of a conductor and the proper identification of the conductor. There is no one frequency that will cover all conditions. The low frequency is most useful for cable conductors and tracing over long distances. The power output of the low frequency transmitters is not regulated as it is with radio frequency transmitters, which allows for high-power low-frequency transmitters (audio frequency). Low frequency does not couple to adjacent lines and is the best frequency to use, if possible. A good rule is to start with the lowest frequency and work up to the lowest frequency that will work on that conductor. A good low frequency is in the 8 KHZ to 9 KHZ range. Transmitters lower than 8 KHZ are too low

for induction and can create power harmonic interference. The 8 KHZ to 9 KHZ is the most useful general purpose frequency as it offers high, power, induction, use of the clamp, good isolation, limited coupling to other lines and will not cause any power interference.

The medium frequency, those from 33 KHZ to 120 KHZ, is easily applied by induction, which allows this frequency to be used in sweeping operations; but it couples to other conductors more easily and will lose its strength in a much shorter distance than the low frequency. It will jump insulators and a good ground is not as critical.

The high frequencies of 120 KHZ and higher are good for the difficult cases of stubs, insulators, poor ground conditions, short lengths of unconnected cable, and is very easy to apply by induction. The high frequency couples very easily to other lines and does not travel very far. Good to have in a locator, but not very good for the normal locate.

Active and Passive Signals

There are two types of signals that can come from buried conductors. The first of the signals is the passive signal that is naturally present in most conductors without any action being taken to put this type of signal on the conductor. An obvious example of this type of signal is a power cable that carries current as part of its normal operation. Less obvious is the fact that the earth is full of power system return currents that flow along the convenient path of lowest resistance provided by pipes and cables. Even less obvious are the radio frequency currents from long wave radio transmissions which penetrate the ground and flow along the pipe or cable whether electrically live or not. Passive signals therefore enable cables to be located, but not identified, as the same signal will appear on every conductor in the area. It must be noted that signal strength has nothing to do with voltage on the line, as it is the current flow that produces the magnetic field to be detected by the locator receiver. The line can be live with a high voltage present and no current flow and no detectable magnetic field can be detected and will be as dangerous as one with a high current flow. The relationship between load current and signal strength is not a direct relationship as all cable systems attempt to minimize the strength of radiated electromagnetic fields by twisting the conductors so that the conductors largely cancel each other out. All passive signals are libel to change and cannot be relied upon for precision measurements as depth. The main application of this type of location is enabling a general avoidance of underground conductors using simple instruments.

Active signals are the result of a deliberate action to either connect or induce a signal from a transmitter onto a target conductor. Active signals enable the conductor to be located, as well as identified and traced, in all situations existing in the underground. With the signal being controlled by the operator, precise work such as depth location and signal strength comparison may be undertaken. With the signal under the operator's control, a choice of frequency, power, grounding methods, and other critical locating variables are under control and can be changed to make the locate easier and more accurate. The passive method of location is a great convenience to the work crew as a simple location tool, which will enable the crew to avoid conductors under the ground

and thus give them protection against contact with live power cables and other conductors.

There are advantages in combining both active and passive receivers into one unit. Combining the two modes of detection into a single unit allows conductors that have been located in a sweep by the passive method to be traced and identified by the active method. When an excavation is planned to a conductor, a sweep in the passive mode will check to see if any other conductors from other utilities are at risk of being damaged. At no time should a passive location be used to mark the path and location marks be placed on the ground as the location of the conductor.

Detection and Location of Signal Sources

A coil will produce a voltage when passed through any alternating magnetic field, pulsating DC or AC. This minute voltage is electronically amplified to produce a visual response and an audible response by the receiver. A coil placed at right angle to the conductor, and directly above the conductor, will produce the strongest response. This will happen because the full alignment of the coil of the receiver will be with the field direction so that it is linked with a higher proportion of the field. A horizontal aerial gives two pieces of information—conductor and conductor direction. The horizontal antenna locates the conductor by using the peak method of looking for maximum signal strength over the conductor. The horizontal antenna is preferable for sweeping, locating and tracing applications. While being a little harder to use, it will not create the problems seen with the null method.

The vertical orientation of the antenna produces a completely different effect, as the flux linking the core falls sharply to zero as the antenna reaches a position directly above the conductor. While the null or no signal is easier to detect than the peak or maximum signal, it is more prone to interference and less accurate than using the peak method. Also, the null signal gives no direction of conductor direction, which makes it less suited to normal location tasks. The null method when used should be verified by using the peak signal often. The null method is also a useful cross check when using the peak method.

The multiple antenna instrument overcomes the limits of just having a single method of location (peak or null). The location of a conductor in a situation where it is the only conductor is simple and can be done with a single antenna locator instrument. Conductors are usually adjacent to other conductors, as well as being under overhead power lines, and subject to other forms of electromagnetic interference. The results from using a single antenna receiver can become confusing, or the interference may render the location instrument ineffective. A significant advantage of receiving the signal at two or more antennas is that the outputs can be compared and analyzed by both the instrument and the user. By comparing and rejecting all signals other than those that are the strongest, the multiple antenna instrument can be used with good results in areas where single antenna units are made ineffective. The multiple antenna system also enables the locator to have automatic depth measurement, once the conductor has been pinpointed. The circuitry does all the math to provide a depth reading by measuring the rate the signal strength is

decreasing, knowing that the signal decreases in a direct relationship to the distance the signal antennas are apart and changes with the distance the antenna is from the conductor. This is an electronic principle and, if required, this quick and easy method can be verified by triangulation.

Location

When a signal is detected in either the peak or null mode, continue along the route of the cable, locating as you move down the path. For the peak method, move the receiver side to side and observe maximum response over the center of the conductor. At maximum signal strength, the receiver is over the conductor. Keep moving the receiver from side to side and follow the direction of maximum response, watching at all times for the highest signal strength.

To use the unit in the null method, cross over the path of the conductor and look for the minimum response. An increase in response on each side indicates a target has been located. The conductor is located under the spot of the conductor. Periodically go back to the peak mode to confirm position. In the newer locators, there are left/right arrows that point the direction of the target conductor. Although the peak method of location of a conductor is more difficult to identify, it is known to be more accurate than the null method.

Depth Readings

Depth readings can only be accurately obtained from signals when using the active transmitter method of location. If passive mode is used, it is very subject to changes in signal strength, which is not in the control of the equipment operator. For accurate depth readings, the unit should rest on the ground and be perpendicular to the conductor. Be aware that this is an electronic principle and not a law of physics.

Glossary/Tech Tips

A-FRAME: The conductive unit used to detect ground faults. Most plug into the locator receiver, but there are models that are stand alone with an electronic package.

ACTIVE LOCATING: Locating an underground conductor by a signal from the locator transmitter.

AUTOMATIC GAIN CONTROL (AGC): A feature of a receiver whereby the gain or sensitivity of the receiver is changed automatically, in response to the wide range of field strength encountered in locating, to achieve optimum ease of use and fast, accurate locating.

BLEED-OFF or BLEED-OVER: The affect wherein the signal from the conductor being located jumps to an adjacent line without any electrical connection. This coupling, which occurs more readily at the higher frequencies, results in a weaker signal on the conductor

to be located as well as a false signal on other conductors. This problem can be reduced by the selection of a lower frequency for the location.

BLIND SEARCH: A technique used to find conductors in an area with unknown buried utilities and with no direct connection to the utilities. Also known as sweeping the area. This method works best with the higher transmitter frequencies.

CABLE FAULT OR SHEATH FAULT LOCATING (SFL): The process of locating an earth fault by measuring the electrical voltage on the ground above the fault that is caused by the current leaking into the ground around the fault. An "A" frame and receiver are used to measure the voltage along the ground looking for the fault.

CENTERLINE: An imaginary line above the conductor being traced that is directly above the line being traced. The center of the display that indicates the locator is to the left or right of the conductor.

COMMON-BONDED CONDUCTORS: Conductors that are electrically connected together at some point. Conductors common bonded to the target conductor will also carry the signal, making it difficult to locate the target beyond the common bond. This problem can be reduced by using lower frequencies and shorter location distances.

CONDUCTIVE ATTACHMENTS: Accessories used with the locator transmitter for direct connection. The most common are the cables supplied with clips on the ends.

DIRECT CONNECTION: The connection of the locator transmitter to the target conductor by the use of cables with one line going to the conductor and the other going to ground. This method is the most widely used and provides maximum power to the conductor being located.

LEFT/RIGHT GUIDANCE: Where the display of the locator receiver indicates the distance and the direction to the conductor being traced. Left/Right guidance provides an indication of the conductor being to the left or right of the receiver location.

FERROMAGNETISM: The property of some materials to influence an external magnetic field. These materials distort the earth's magnetic field, and it is this distortion of the earth's field that is detected by ferromagnetic locators. This type of locator is very useful in detecting objects rather than lines.

FREQUENCY: The number of times that a signal reverses its direction in a second or cycles completed in one second. The proper selection of frequency is important in conductor location. Measured in Hertz (HZ) and thousand Hertz (KHZ) in the location industry.

FREQUENCY ALLOCATION AND MAXIMUM POWER: Regulated by the Federal Communications Commission (FCC) in the Code of Federal Regulations, 47 (Telecommunications), part 15, section 15.213. The FCC regulates the frequencies and

power level that may be used in underground locating equipment. Below 9 KHZ any frequency may be used as well as any power level.

GAIN: The amount the signal found at the antenna of the receiver is increased before it is processed and displayed. The signal is very small at the antenna and must be increased many times before it is of use as a location signal.

GHOST CONDUCTOR: A false indication by the receiver that would indicate the presence of a conductor. The ghost signal is a result of using the receiver in the null mode and will be eliminated by the use of the peak mode of location.

GROUNDING: A return path for the signal through the soil. Grounding provides a continuous and complete path for the signal to travel over the line and back to the transmitter. Without a ground path, the location signal will not flow and there will be no signal for the receiver to detect.

HIGH FREQUENCY LOCATION: The high frequencies (above 120 KHZ) provide the best performance on conductors with grounding problems and poor continuity due to corrosion or the use of insulators. The signals at high frequencies will go shorter distances and are more susceptible to bleed-over than signals at lower frequencies.

INDUCTIVE COUPLING: A method of applying the signal to the conductor without a direct electrical connection. There are two types of inductive coupling—the direct and indirect.

<u>Direct inductive coupling</u> is where the signal from the transmitter is applied by means of an inductive clamp to the conductor. This mode provides good signal transfer and good isolation for the signal. Used on drops and service wire to eliminate the need for direct connection.

<u>Indirect inductive coupling</u> is a method of coupling the signal by which the signal from the transmitter is applied to the conductor by means of an antenna. The transmitter is placed near the conductor to be located and the signal is induced in the conductor. This method of applying the signal should be avoided and used as a last resort.

INDUCTION: The generation of current in one conductor due to current running in an adjacent conductor even though there is no common bond between the conductors. Signals can be induced by air coupling, from adjacent conductors, and from overhead power lines.

INDUCTIVE CLAMP: A device used to induce signal into a line without an electrical connection. The jaws of the clamp open allowing the conductor to be placed in the clamp and signal transfer to take place.

LOW FREQUENCY: Low frequency locator signals are the least susceptible to bleed-over and jumping, and will travel further than medium and high frequencies as there is no

limit to the amount of power put out by the transmitter. The low frequency signals require a good ground, and impedance matching is critical. Low frequency signals are unable to jump discontinuities in the line such as insulators and poor bonding.

MAGNETIC FIELD: The force field around a permanent magnet or a conductor with electric current flowing. It is this field that makes it possible for locators to work.

MANUAL GAIN CONTROL: Where the gain of the receiver can be adjusted manually to pick up the signal on the conductor. The fault with manual gain is that it often is set too high and conductors appear everywhere. Should only be used by the experienced locator tech or miss locates will result.

MEDIUM FREQUENCY: Locators in the lower radio range of 33 KHZ to 120 KHZ range. The signals in this range are regulated by the FCC and will travel farther and be less likely to bleed over than the high frequency signals. Signals in this frequency range will work well in the inductive mode of operation.

OVERHEAD INTERFERENCE: The interference caused by overhead lines. The signal when picked up by the receiver will interfere with the signal from the conductor being located. Easy to determine if this signal exists by raising the unit up and checking to see if the signal strength goes up. If the signal strength rises, the signal is coming from the air; if it decreases, the signal is from the ground.

PASSIVE LOCATING: A method of locating where no transmitter is required. The current in the line is generated by electromagnetic fields in the environment such as those generated by power lines and radio stations. This technique, while quick, is prone to errors and should be used for preliminary location and not in marking the conductor.

SIGNAL STRENGTH: A feature of the receiver that shows visually the relative strength of the signal being received. The signal strength depends on the current flow in the conductor and the depth along with other factors. Changes in signal strength are an indication that something is happening with the conductor.

SONDE: A small transmitter that is pushed or pulled through the conductor when possible to find faults in conductors such as pipes and ducts.

TRIANGULATION DEPTH: The estimate of depth obtained by the triangulation method. In the triangulation method, the conductor location is established as accurately as possible. The receiver is then tilted by 45 degrees and the location corresponding to maximum signal strength is then established and marked on each side of the conductor. The depth is approximately equal to one half the distance between the two location marks placed with the receiver at the 45-degree position. This is an accurate method to determine depth on level ground, while an error factor is present when the ground is not level.

ELECTRICAL

WORKPLACE SAFETY

Safe Work Practices

&

Regulatory Requirements

Hugh Hoagland, ArcWear.com

Bill Shinn, P.E., e⁻Hazard.BIZ

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Order of the Day

ELECTRICAL
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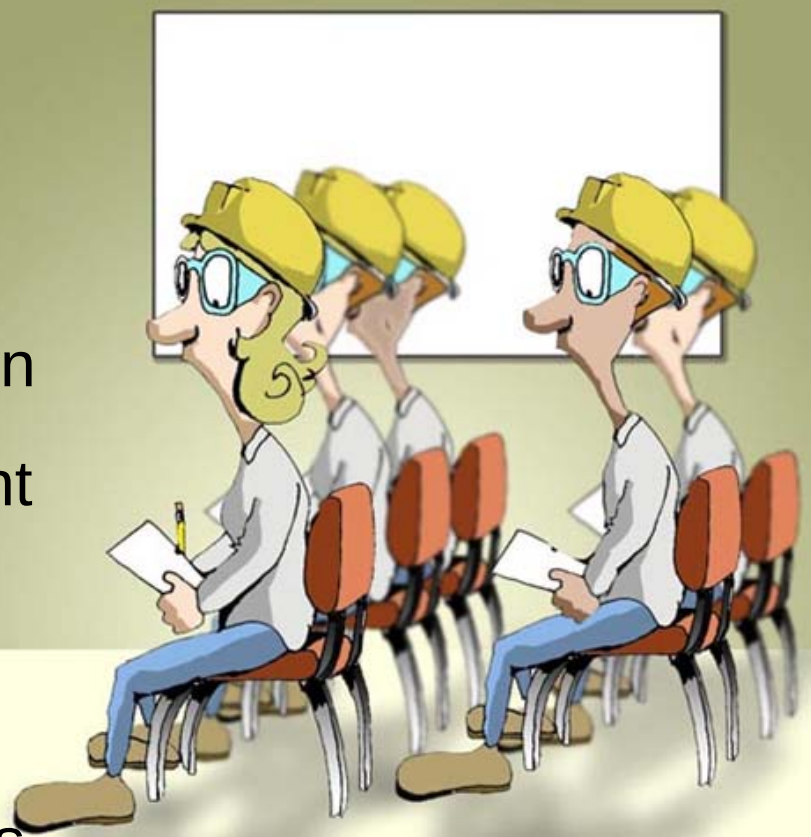
- Safety Facts
- Governmental Regulations & Industry Standards
- Electrical Hazards & Protection
- Personal Protective Equipment
- Flash Hazard Assessment
- Safe Work Practices
- Working On or Near Live Parts
- Be Safe Out There



Safety Facts

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WORKPLACE SAFETY

Why be concerned about electrical safety?

- Personal safety
- Safety for your fellow workers
- Comply with applicable regulations

Safety Facts

ELECTRICAL
WORKPLACE SAFETY

- Average of 4,000 non-disabling and 3,600 disabling electrical contact injuries annually in the United States.
- One person is electrocuted in the workplace every day.
- Electrocutions are the fourth leading cause of traumatic occupational fatalities.
- Over 2,000 workers are sent to burn centers each year with electrical burns.

Safety Facts

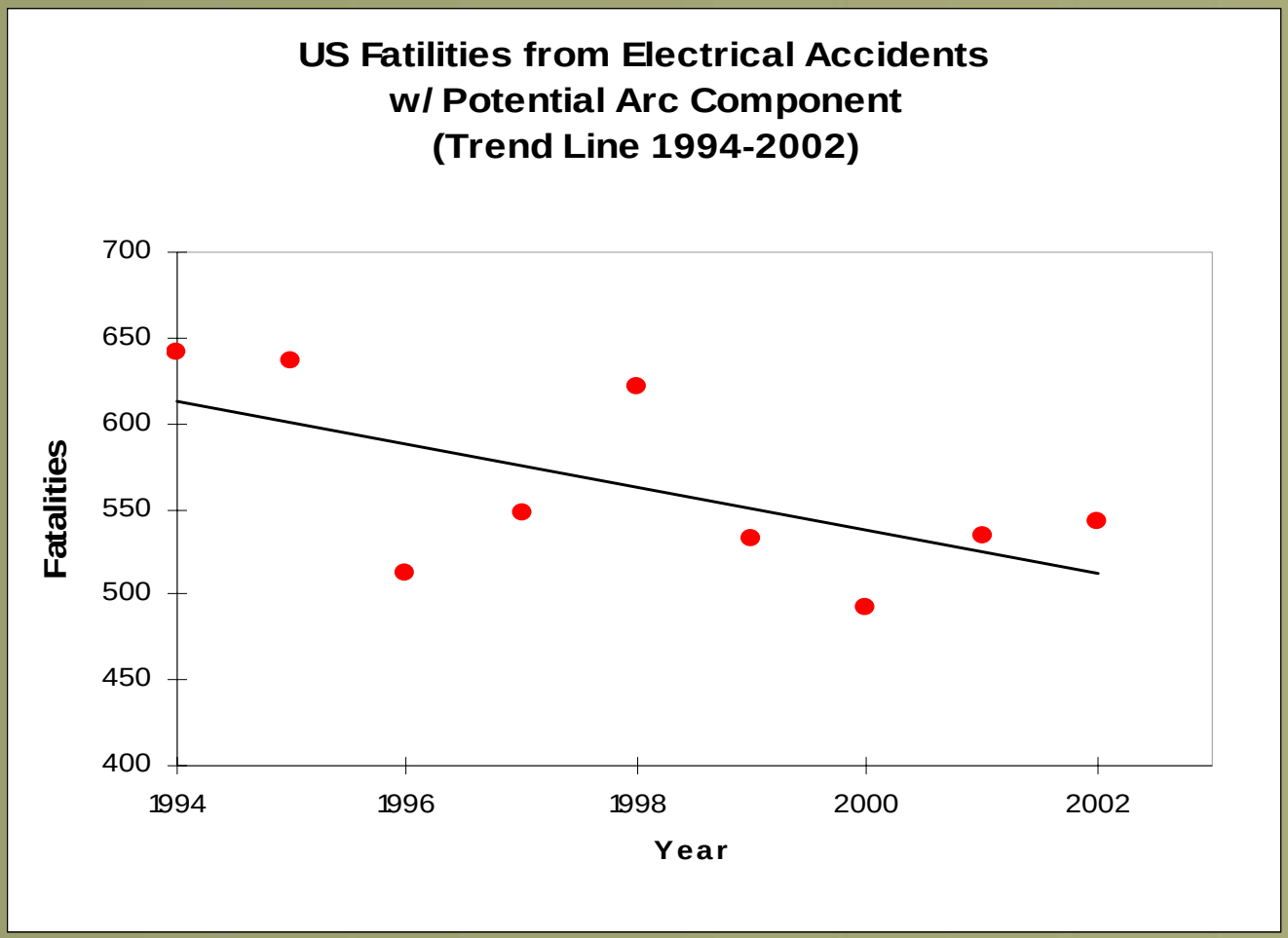
ELECTRICAL
WORKPLACE SAFETY

- Utility Industry 10 year study 120,000 workers
- 125 injuries/yr.
- 77% electrical arc injuries
- 21% permanent disabilities
- 2.4% fatalities

Based on ED France data, IEEE Presentation from M. Capelli-Schellpfeffer, M.D.
Electrical Trauma Research Program (University of Chicago)

Safety Facts

ELECTRICAL
WORKPLACE SAFETY



Statistics from BLS website, Belinda Cannon, USDOL/OSHA. Analysis by Hugh Hoagland ArcWear.com. To see calculations visit www.arcwear.com/stats.mht

Safety Facts

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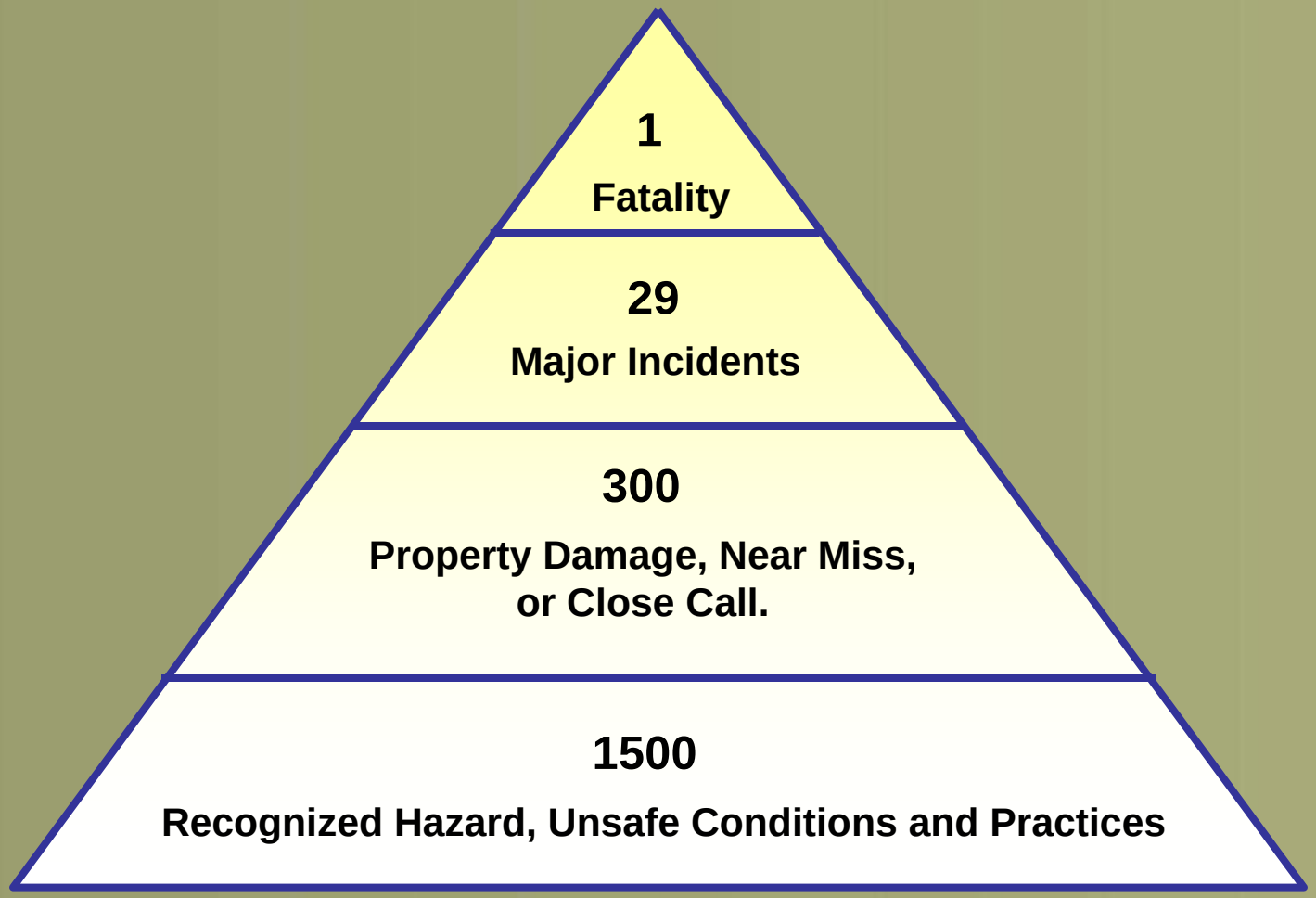

Classic Heinrich Textbook Model for Incident Occurrences

Safety Facts

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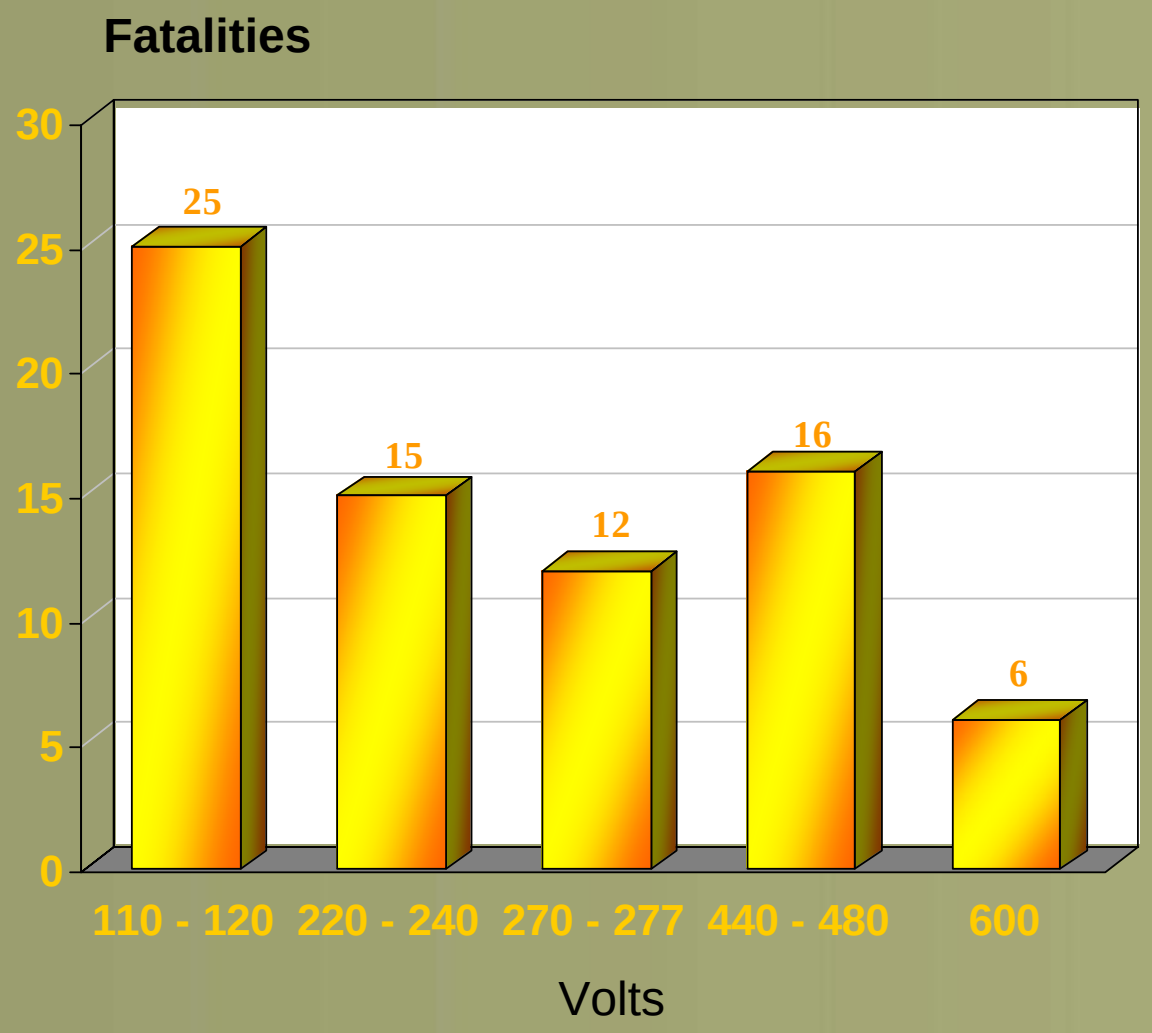
U.S. Industrial Low Voltage Fatalities



Safety Facts

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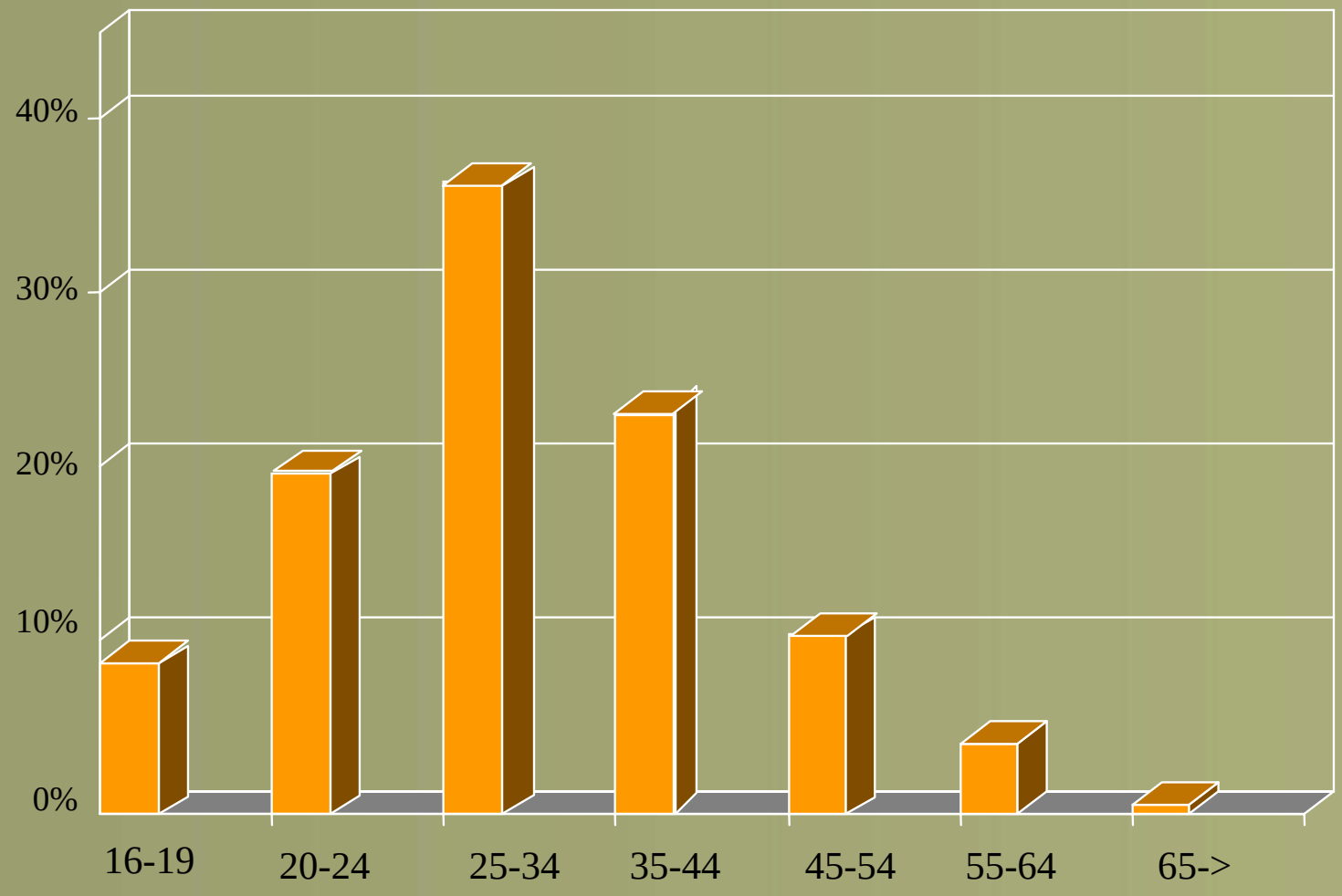
Fatal Electrocution by Age

1982-1994



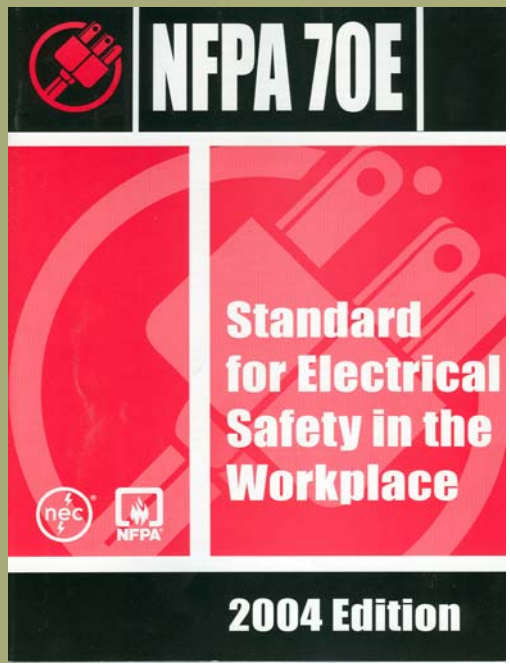
OSHA and NFPA 70E

- OSHA adopted the 1968 edition of the National Electrical Code (NEC).
- The NEC insufficient for personal safety – No work practices.
- In conjunction with OSHA, NFPA first published 70E in 1979.

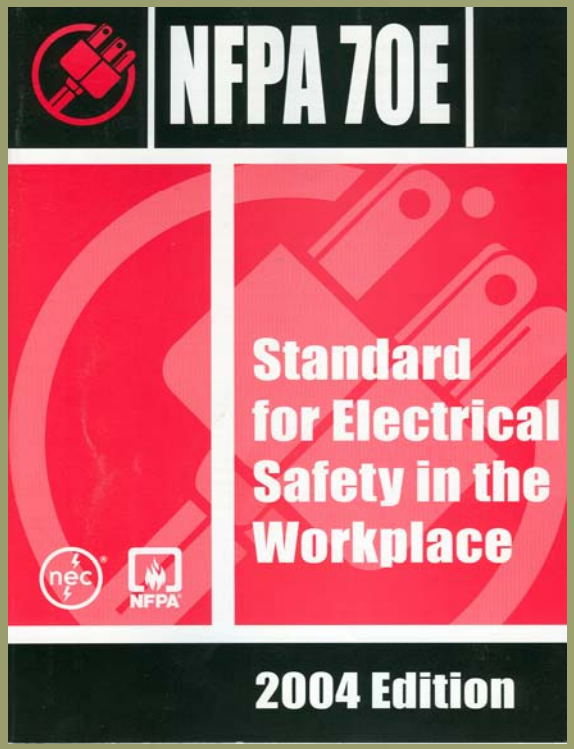
NFPA 70E

Four-part structure:

- Chapter 1 – Safety-related work practices
- Chapter 2 – Safety-related maintenance requirements
- Chapter 3 – Safety requirements for special equipment
- Chapter 4 – NEC-related installation material



Strategies Embedded in NFPA 70E (2004)



- Electrically safe work condition
- Training
- Planning
- PPE

The focus of this training program is 70E Chapter One, and also meets the requirements of OSHA 1910, Subpart S 331-335.

100 cal/cm^2 Arc

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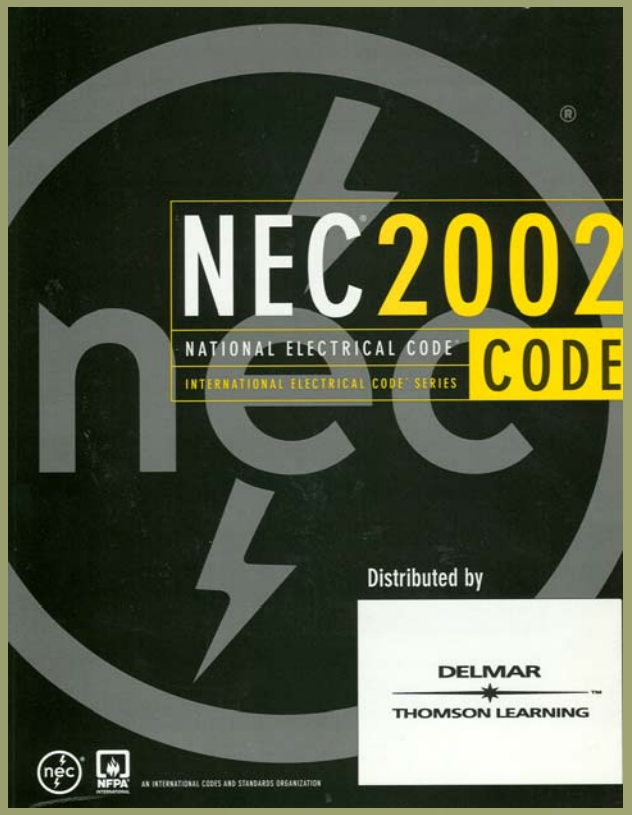
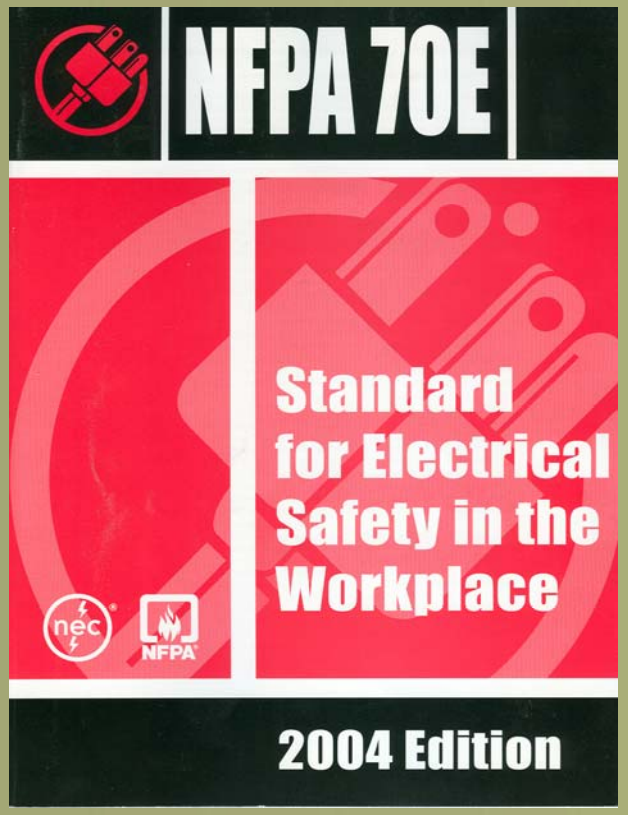
8kA, 120 cycles, FRC/FR Wool Jacket

Difference between NFPA 70E and NEC



How you built it.



How you work on it.

ELECTRICAL HAZARDS

- Types of hazards
- Types of injuries
- Common location of hazards
- Protection strategies

Electrical Hazards

ELECTRICAL
WORKPLACE SAFETY

What are the electrical hazards?

- Fire ignition
- Electric shock
- Arc flash
- Arc blast

Associated hazards:

- Falls
- Smoke inhalation
- Confined space entry

Electrical Hazards

ELECTRICAL
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Before

During

Electrical Hazards - Shock

ELECTRICAL
WORKPLACE SAFETY

Shock: Sudden stimulation of nerves and convulsive contractions of muscles caused by the discharge of electricity through the body.

Webster's Dictionary

Electrical Hazards - Shock

ELECTRICAL
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- How many have experienced a shock?
- How many have gotten “hung up” or “couldn’t let go”?
- How many have gotten “hung up” more than once?
- How many have been exposed to an electric arc?

Electrical Hazards - Shock

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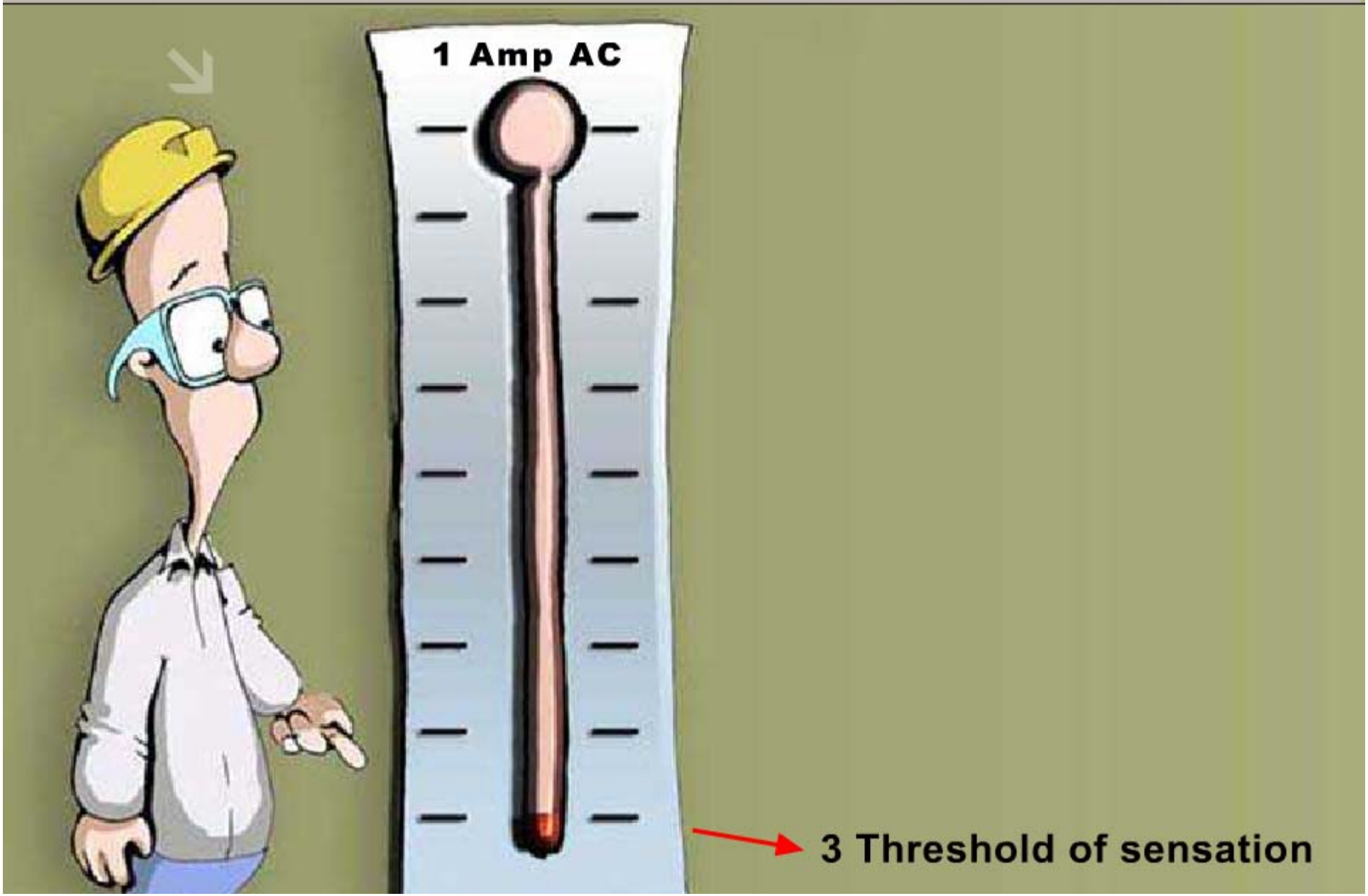

Electrical Hazards - Shock

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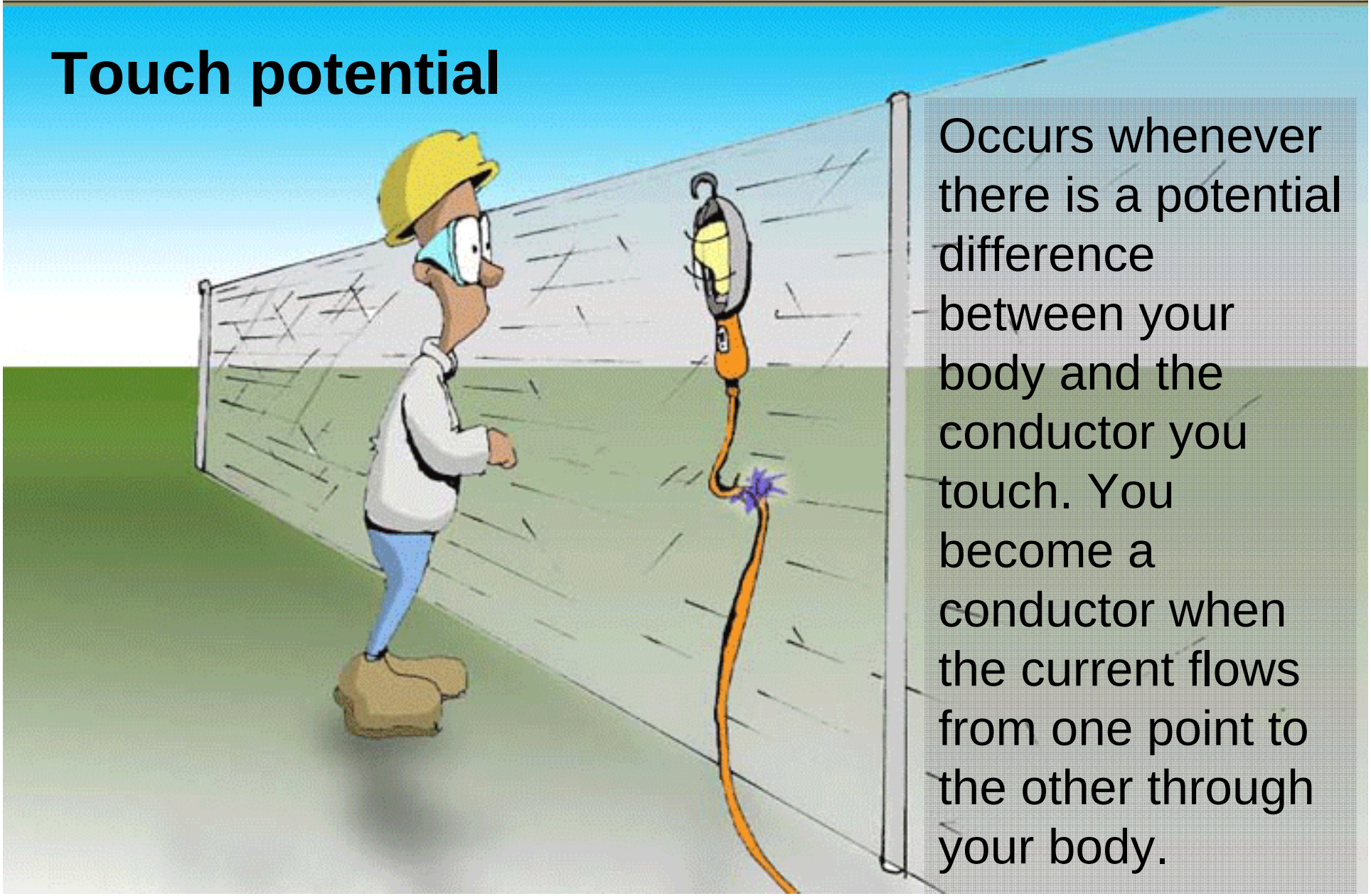
Touch potential



Occurs whenever there is a potential difference between your body and the conductor you touch. You become a conductor when the current flows from one point to the other through your body.

Electrical Hazards - Shock

ELECTRICAL
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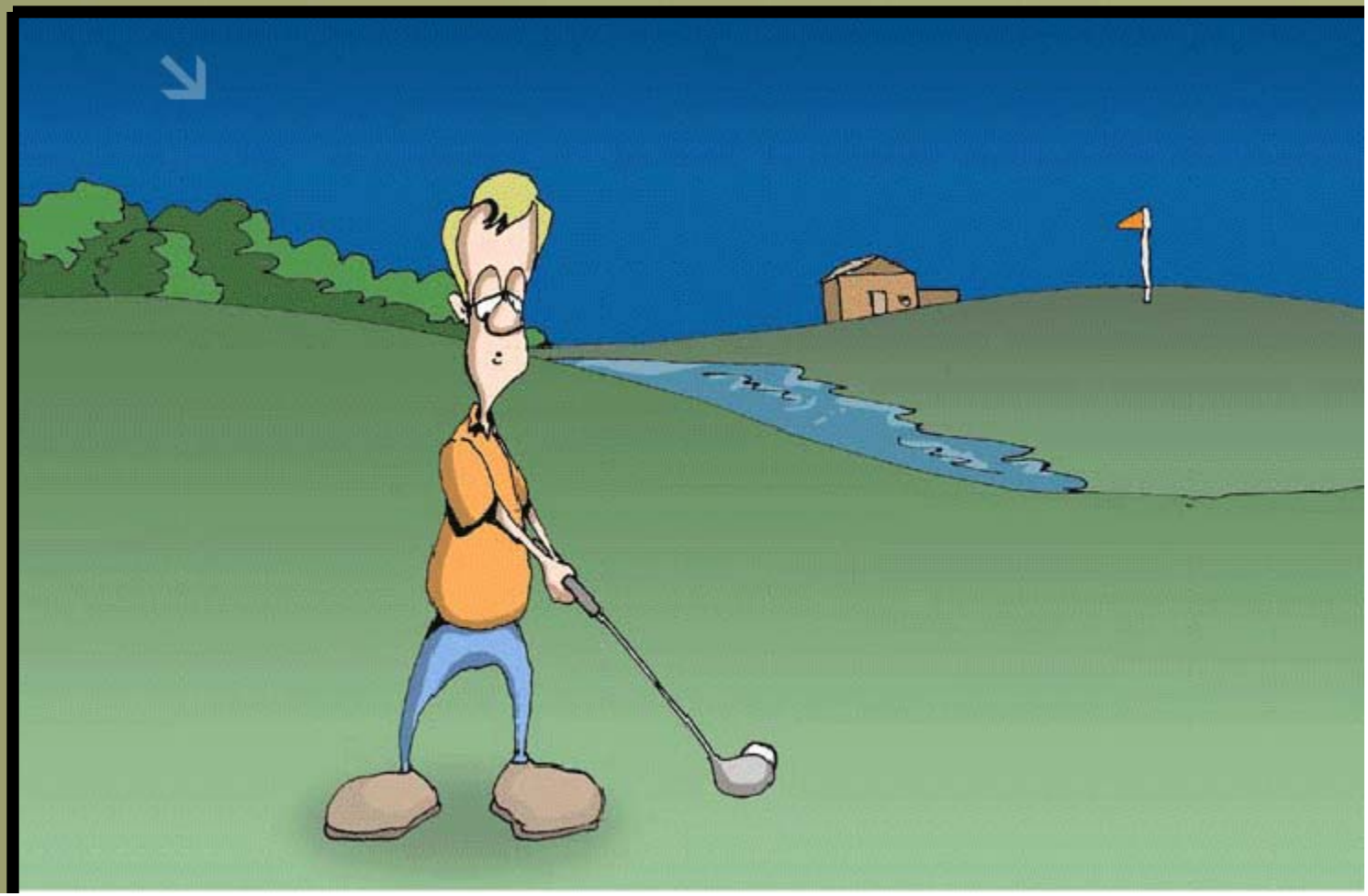
Step Potential

Occurs when there is a difference in earth potential between the position of an animal's or person's feet. Current can flow from one foot to the other.

As little as 1/10th of an amp passing through the body can be fatal.



Electrical Hazards - Shock

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Condition	Current (mA)	
	Dry	Wet
Finger Touch	0.1 to 3.0	8 to 30
Hand Holding Wire	2.4 to 8	20 to 40
Finger-Thumb Grasp	4 to 12	24 to 60
Hand holding pliers	12 to 24	40 to 120
Palm Touch	15 to 40	60 to 120
Hand around 1 1/2 Pipe	40 to 120	80 to 240
Two Hands Around 1 1/2 Pipe	80 to 240	160 to 480
Hand Immersed		240 to 600
Foot Immersed		400 to 1200
Human Body, internal, excluding skin	120 to 600	

This table was compiled from data developed by Kouwenhoven and Milnor

Electrical Hazards - Shock

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Ohms Law

I (amperes) = V (volts) / R (ohms)

I = 480 volts / 1000 Ω
= 0.48 amps
(480 mA)

Human body resistance (hand to hand) across the body is about 1000 Ω

I = 120 volts / 1000 Ω
= 0.12 amps
(120 mA)

The NFPA 70E considers 5 mA to be the safe upper limit for children and adults.

Exposure to Shock

- A shock requires exposure to a difference of potential.
- The National Electrical Code *reduces* this risk under *normal* conditions.
- NFPA 70E *reduces* the risk under *abnormal* conditions.

Electrical Hazards - Shock

ELECTRICAL
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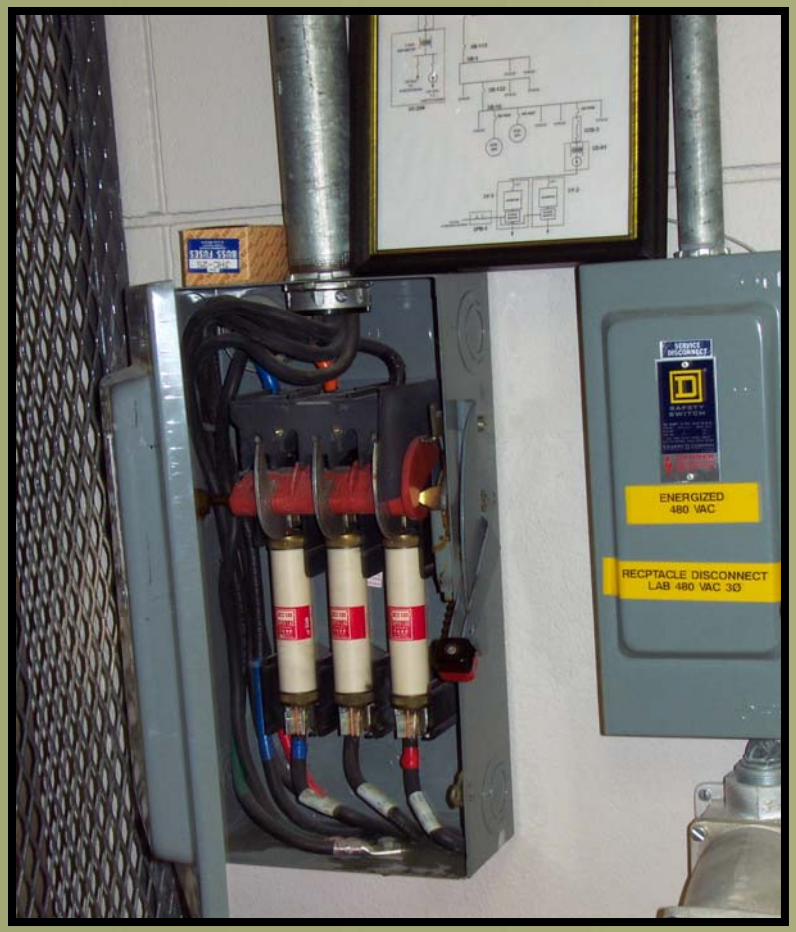
Normal Conditions



Abnormal Conditions

What work practices protect you from electrical shock?

- De-energizing
- Eliminating contact with exposed, energized parts.
- Wearing protective gear.
- Using insulated tools.
- Creating an electrically safe work area.

Electrical Hazards - Shock

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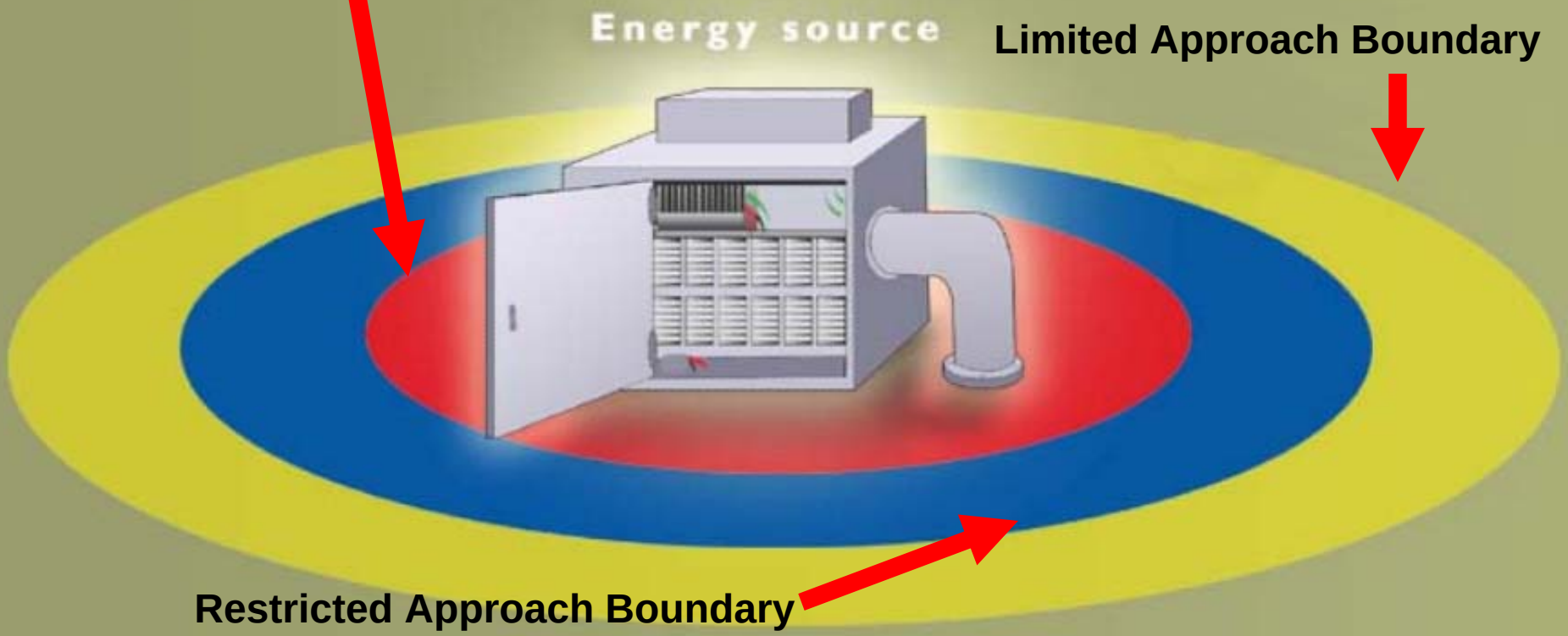
Qualified persons may work up to this boundary.

Prohibited Approach Boundary

Unqualified persons must remain outside this boundary unless escorted by a qualified person.

Limited Approach Boundary



Restricted Approach Boundary

Qualified persons may work up to the restricted approach boundary with no further safety requirements. Working inside the restricted approach boundary requires additional safety practices.

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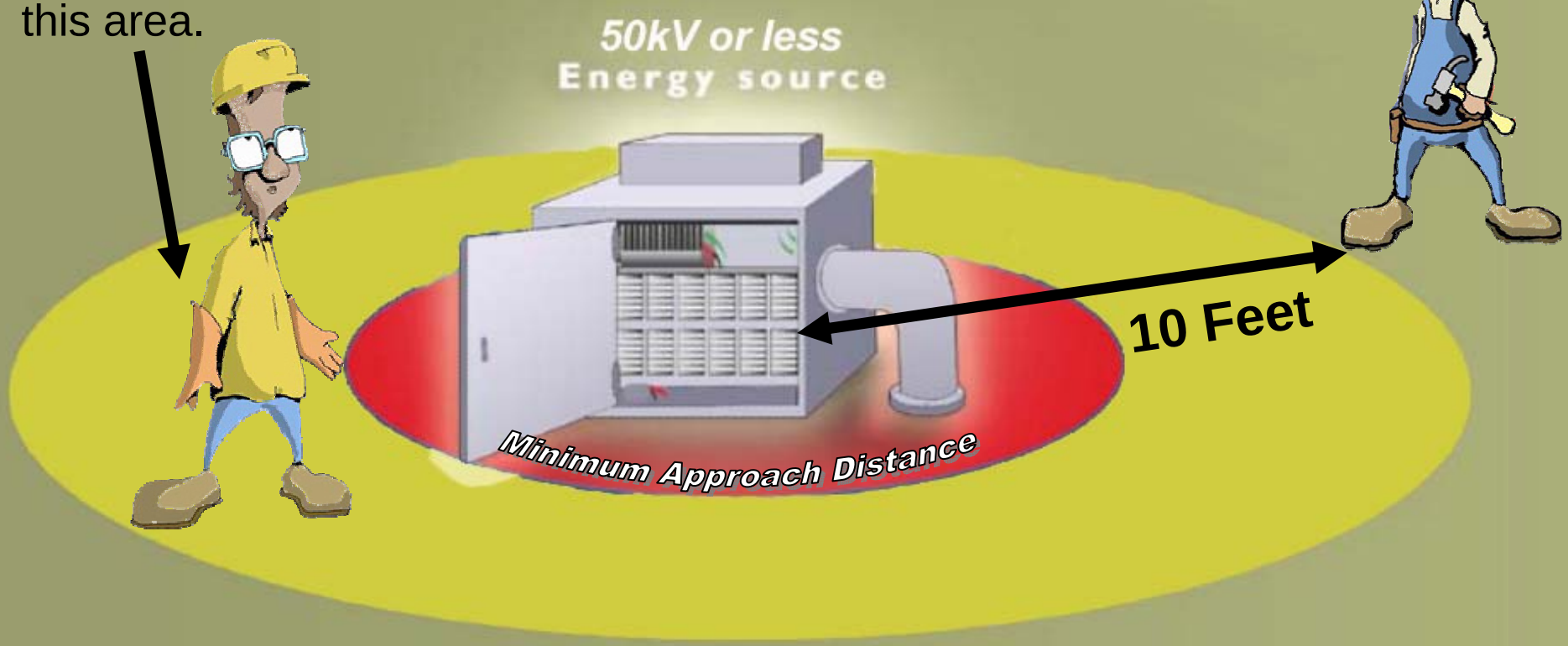
Shock Protection Boundary for High Voltage (50kV or less)

Only high voltage qualified persons are allowed within this area.

All unqualified persons, equipment, and loads must remain at least ten feet from a high voltage energy source rated 50kV or less.



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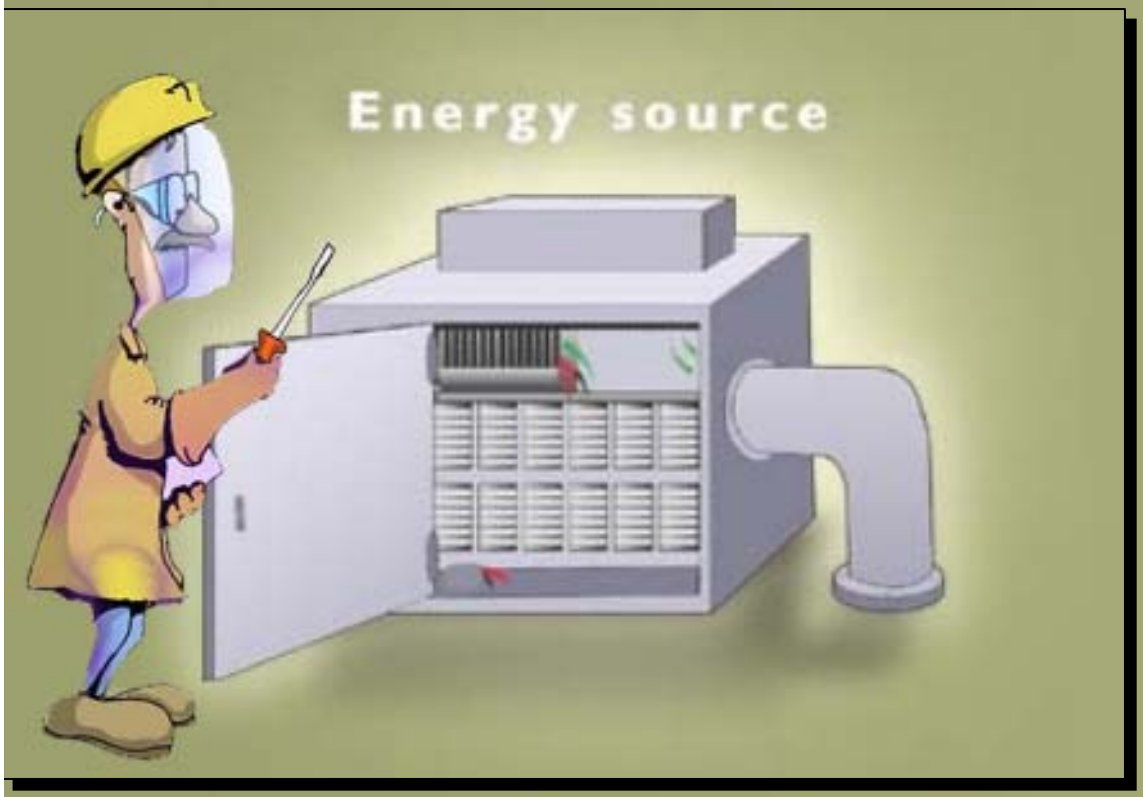
Approach Boundaries for Common Voltages at your Location

NFPA 70E, Table 103.2(C)

What are your approach distances?

ELECTRICAL
WORKPLACE SAFETY

Shock Protection



- Insulated gloves
- Insulated tools
- E Rated Hardhats
- EH rated shoes
- Dielectric shoes

Electrical Hazards - Shock

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Create a safe work zone

Protect personnel from shock hazards by barricading the perimeter of the area to keep persons out.

Protect personnel within the work zone by shielding and barricading exposed, energized parts.

Mitigating Exposure to Electric Shock

- Could the circuit be de-energized?
- If not, what action would minimize the hazard?
  - Cover-up such as roll blanket
  - Permanent barriers such as Lexan finger guards
- What PPE would minimize the exposure?
  - Voltage-rated gloves
  - Insulated tools
  - E-rated hardhats

PPE - Gloves

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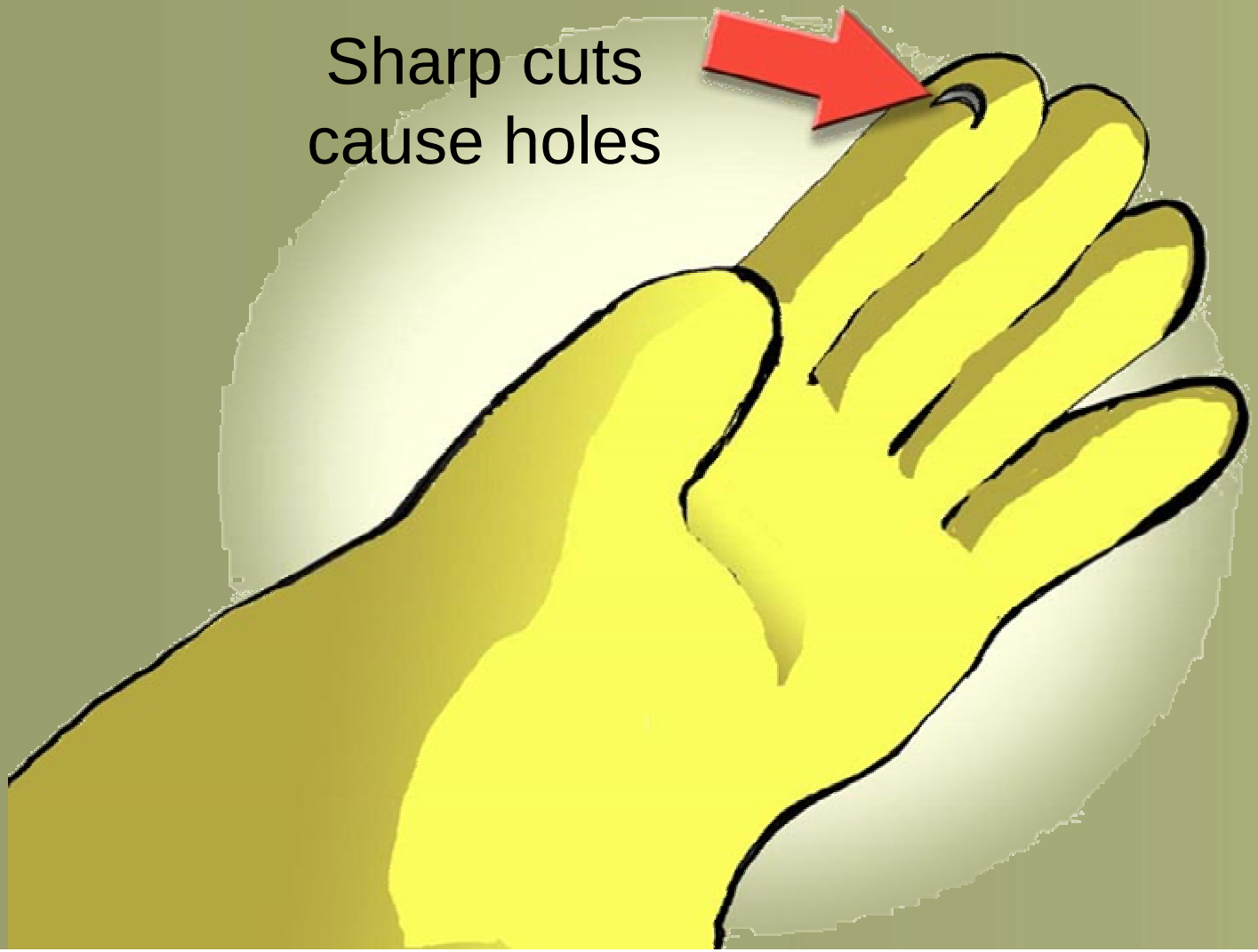
Inspecting



PPE - Gloves

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Inspecting

Ozone damage

Time
Air
Sunlight
Chemicals
Improper Storage

PPE - Gloves

ELECTRICAL
WORKPLACE SAFETY

Inspecting

Cracking

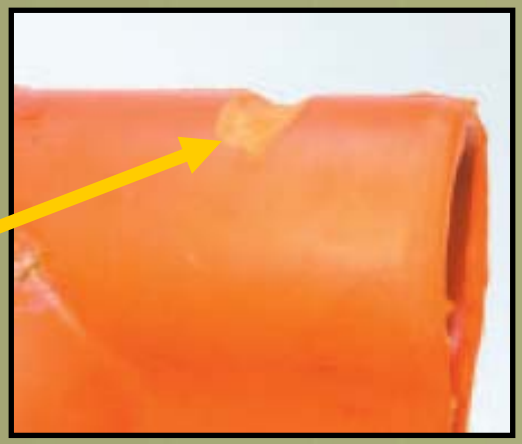
Contamination

Insulated rubber gloves

Leather protectors

Pin Holes

Cuts



Pictures courtesy of Salisbury

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Air Testing and Storage of Rubber Insulating Gloves

Air test your gloves before each day's use.

PPE – Insulated Tools

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Insulated tools – another layer of protection between you and an energy source.

PPE – Insulated Tools

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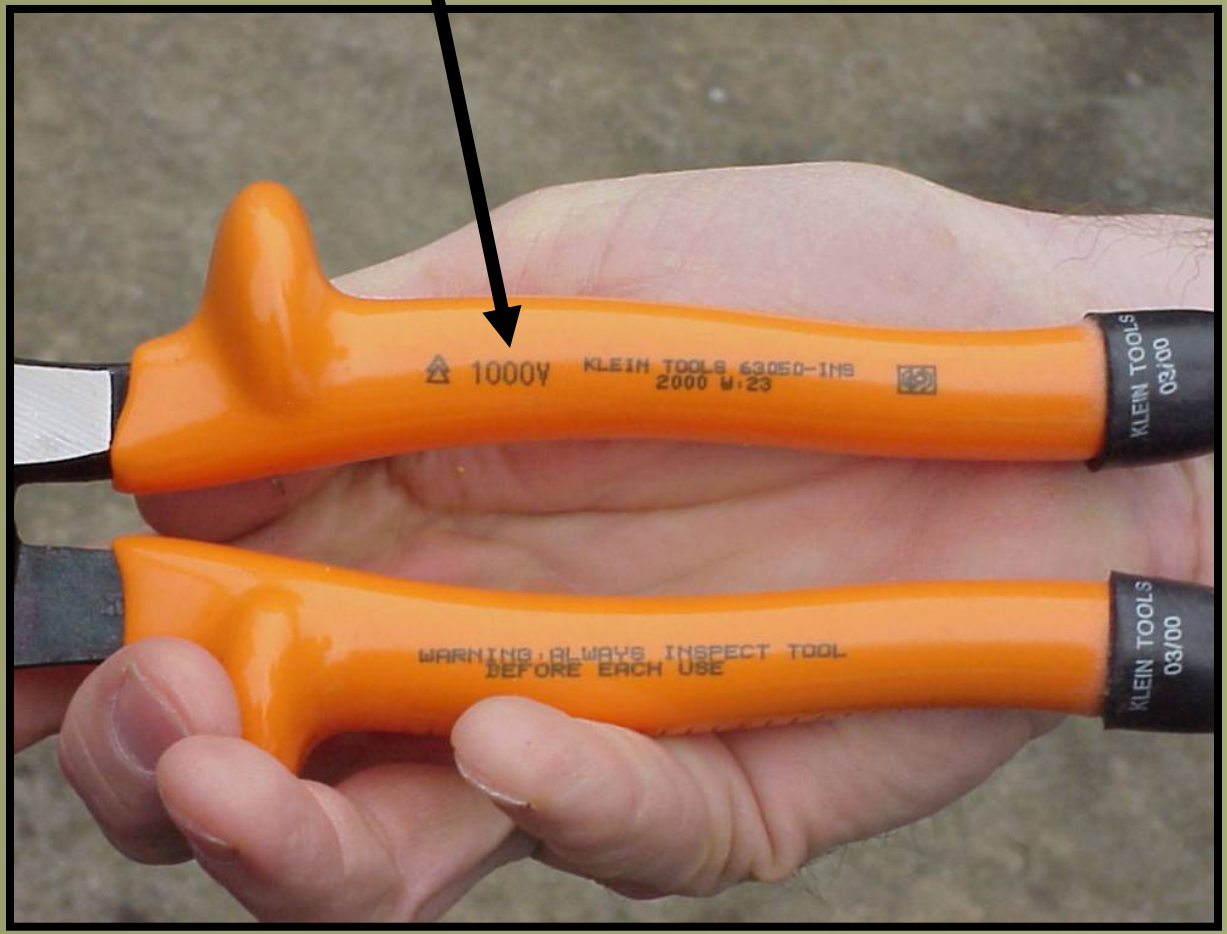
Note the "1000 V" mark on genuine insulated tools.



Electrical Hazards – Arc Flash

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Arc Flash: Violent eruption of energy from an electrical source.

- Arc temperature can reach 35,000°F.
- Fatal burns can occur at distances over 10 feet.
- Over half of all arc flashes occur at 277 volts.

Electrical Hazards – Arc Blast

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Pressure wave caused by the rapid heating of surrounding air. A blast can:

Vaporize copper, expanding it to 67,000 times the original volume.

Explode circuit components creating shrapnel.

Create high pressures enough to cause trauma or throw a worker across a room

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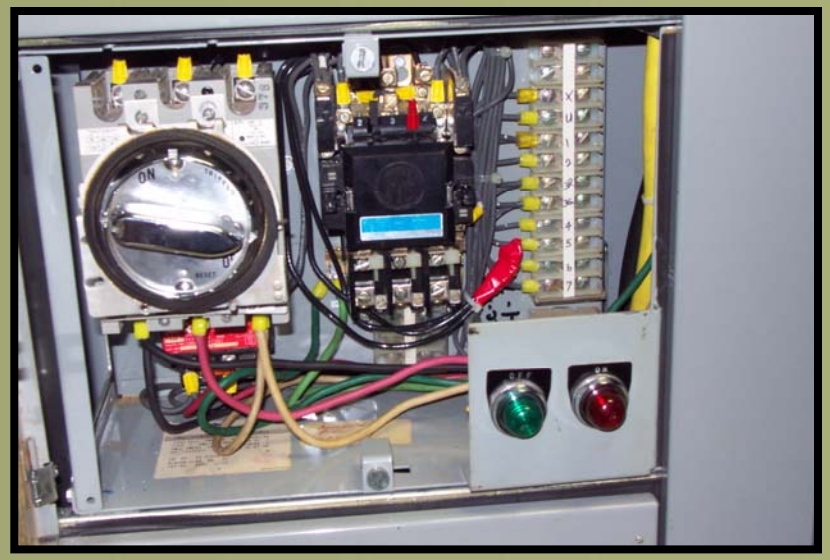
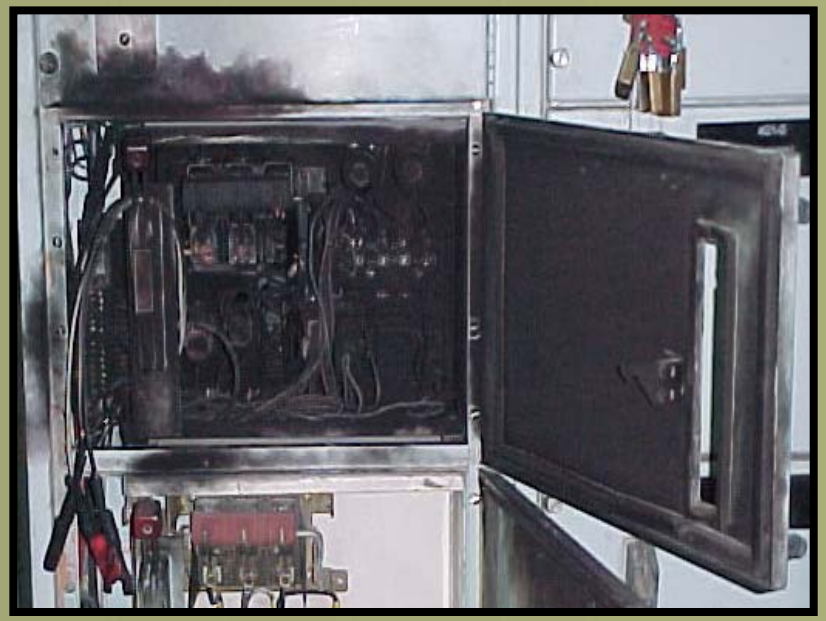
Arc in a Box

Energy can be two to twelve times greater when the arc is an *arc in a box* situation.

Common Places for a Fault

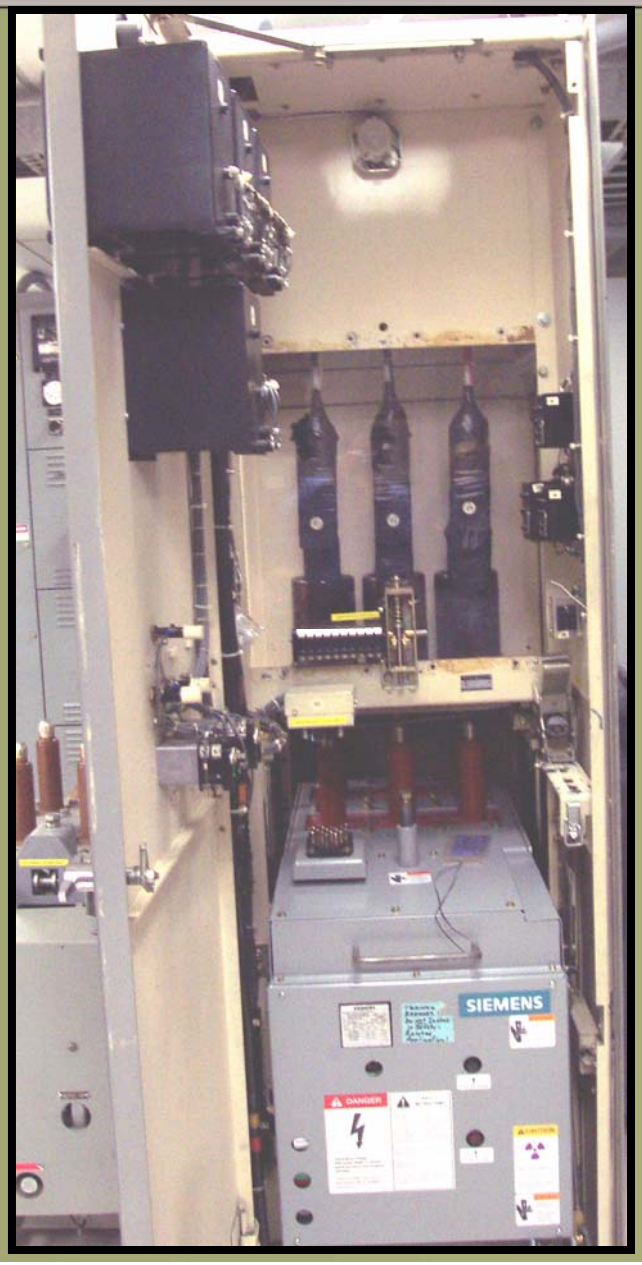
- Motor Control Centers (power plants, industrial)
  - 10-40+ kA
  - Often 20+ cycle clearing times
  - Low voltage





Common Places for a Fault

- Metal Clad Switchgear
  - high fault current availability (especially on secondary)
  - Responsible for many deaths
  - improper use of testing equipment
  - breaker failure



Electrical Hazards – AFH

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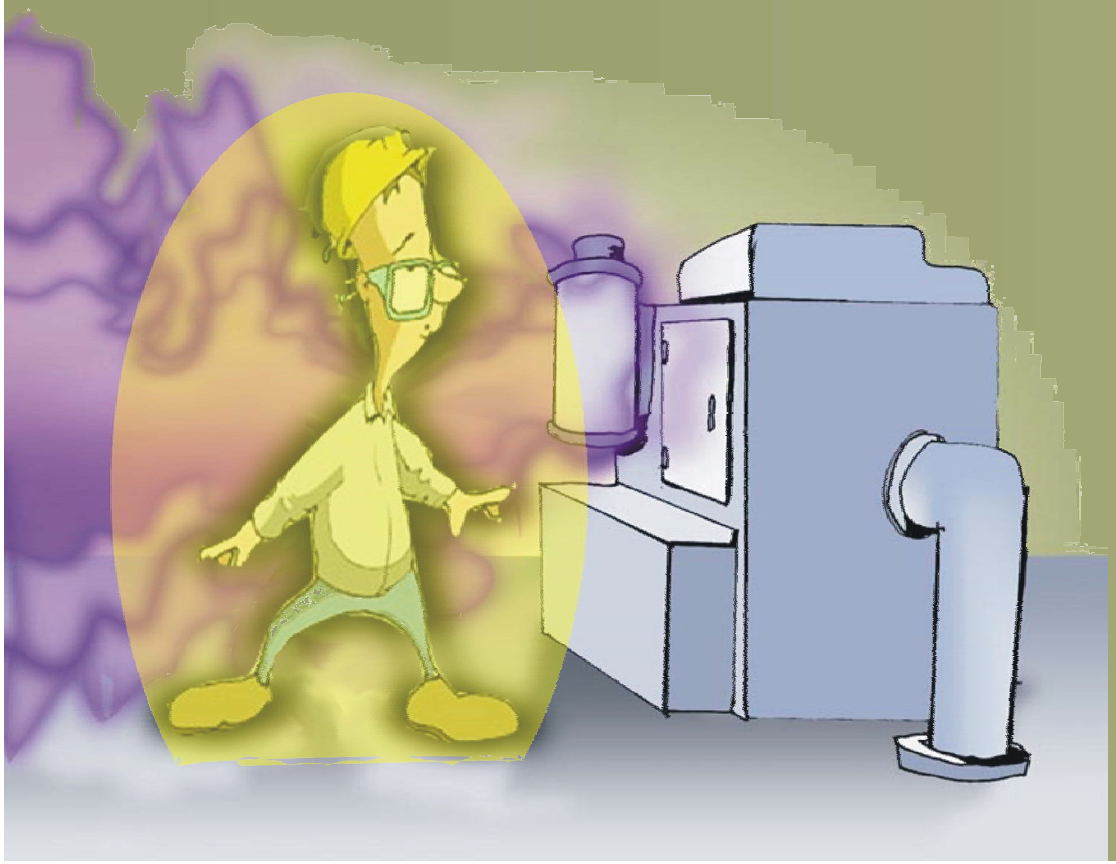
WORKPLACE SAFETY

What work practices protect you from arc flash injuries?



- De-energizing
- PPE
- Distance boundaries
- Arc-resistant equipment

Electrical Hazards – AFH

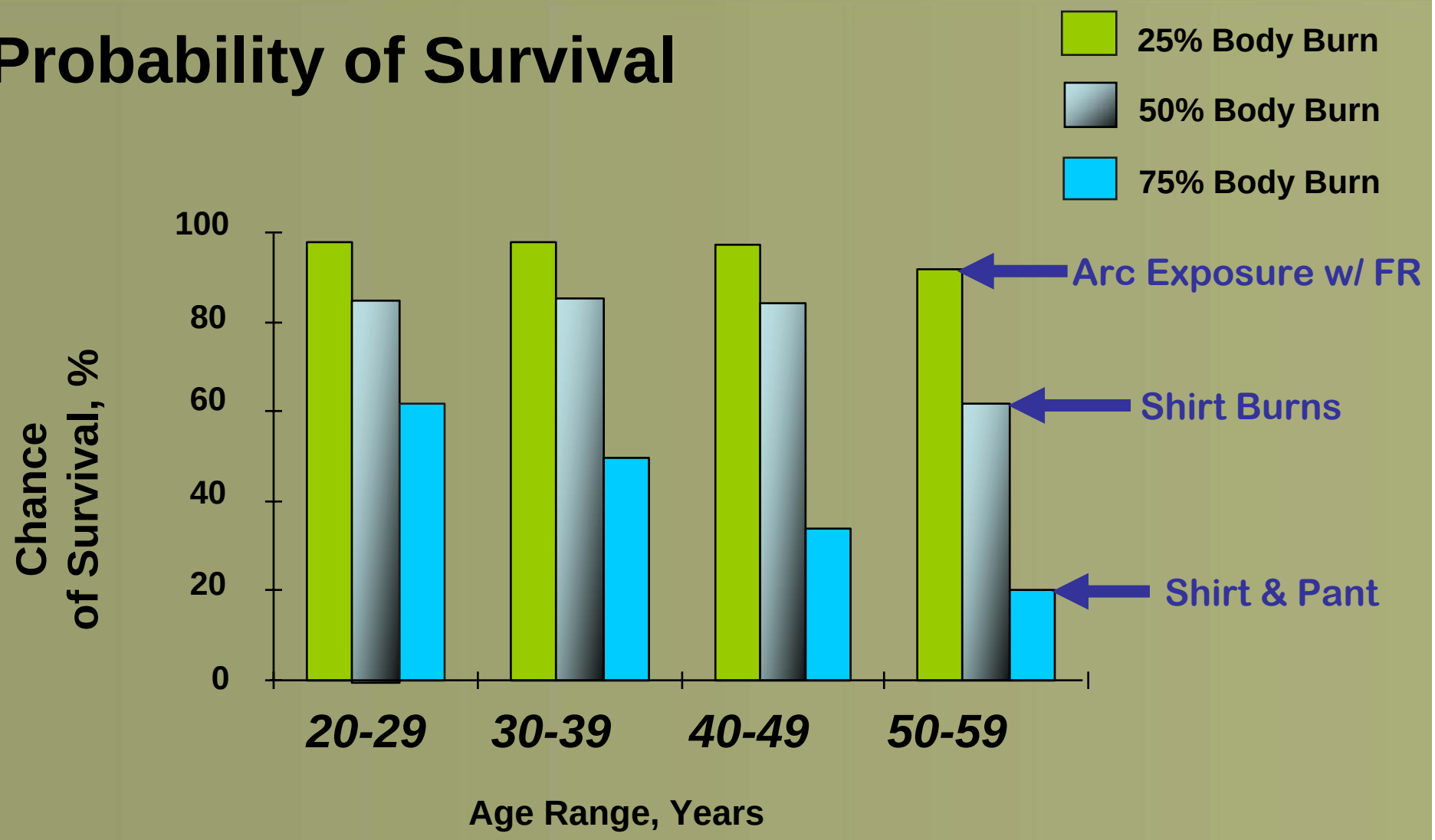
ELECTRICAL
WORKPLACE SAFETY

The right stuff makes a difference

Electrical Hazards – AFH

ELECTRICAL
WORKPLACE SAFETY

Probability of Survival



Source: American Burn Association (1991-1993 Study)

Electrical Hazards – AFH

ELECTRICAL
WORKPLACE SAFETY

Determined distance an arc flash could be projected from an energy source.

Exposure for up to 1.2 cal/cm^2.

Arc Flash Protection Boundary

- Methods to determine flash protection boundaries include:
  - NFPA 70E-2004
    - Tables
    - Calculations
      - NFPA 70E Formulas (Limited to < 601 V)
      - IEEE 1584-2002 Guide for Arc Flash Hazard Calculations

Default Flash Protection Boundary

- A 48” boundary may be used for basic systems:
  - 50 to 600 volts maximum
  - Up to 50KA available and 6-cycle clearing time
  - Other combinations up to 300kA cycles
  - Calculations are permitted

Electrical Hazards – AFH

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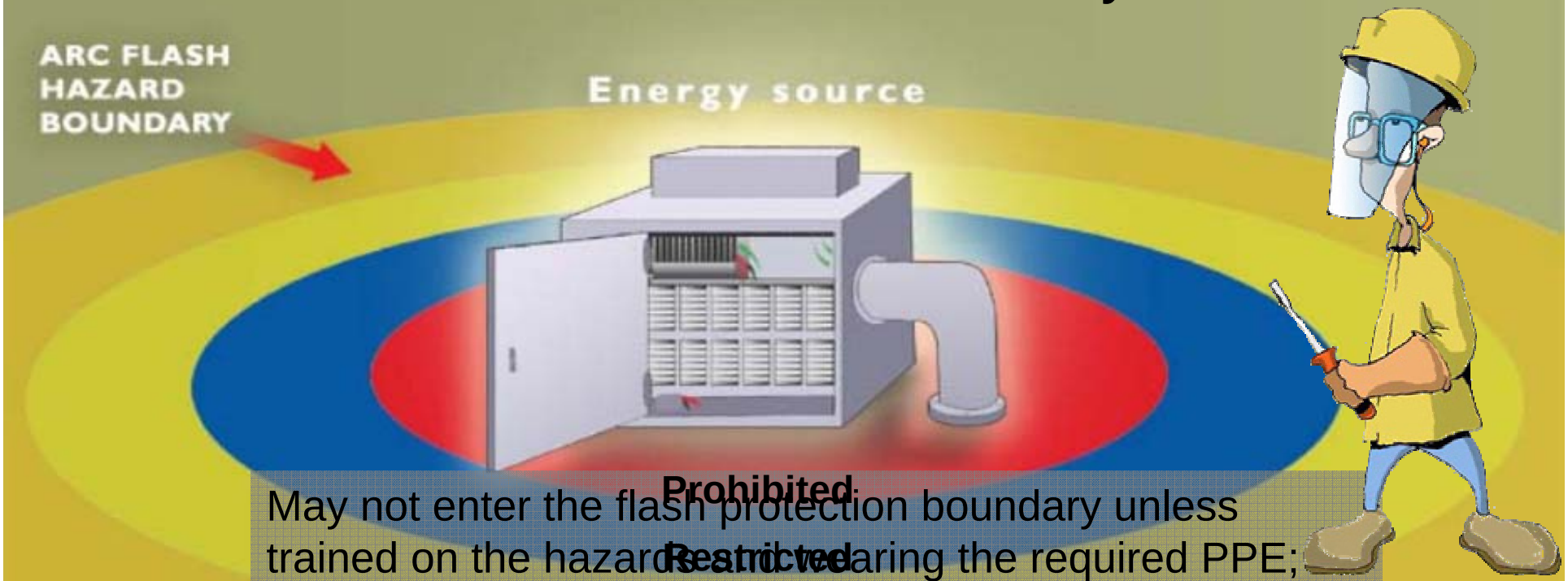
WORKPLACE SAFETY

Two types of boundaries

Shock Protection Boundaries

Arc Flash Hazard Boundary



Prohibited

May not enter the flash protection boundary unless trained on the hazards and wearing the required PPE;

Restricted

May not enter the limited approach boundary unless qualified to do so or escorted by a qualified person.

Limited

ELECTRICAL
WORKPLACE SAFETY

Create a safe work zone

Protect personnel from flash hazards by de-energizing equipment and barricading the work zone.

PPE

ELECTRICAL
WORKPLACE SAFETY

What is PPE?

- Protective scheme for electrical hazards
- Protect specific areas of the body
  - Head, face, neck, chin
  - Eye protection
  - Body protection
  - Hand and arm protection
  - Foot and leg protection

PPE - Gloves

ELECTRICAL
WORKPLACE SAFETY

Right glove for the job

You must have the correct class of glove for the task.

Check the label.

PPE - Gloves

ELECTRICAL
WORKPLACE SAFETY

Class (Label Color Code)	Acceptance proof test voltage A.C.	Acceptance proof test voltage D.C.	Glove labels	Max. use voltage
00 (Beige)	2.5 kV	50kV	10 W.H. Salisbury & Co. ANSI/ASTM D120 CLASS 00 TYPE 1	500V
0 (Red)	5 kV	50kV	10 W.H. Salisbury & Co. ANSI/ASTM D120 CLASS 0 TYPE 1	1 kV
2 (Yellow)	20kV	50kV	10 W.H. Salisbury & Co. ANSI/ASTM D120 CLASS 2 TYPE 1	17kV
3 (Green)	30kV	60kV	10 W.H. Salisbury & Co. ANSI/ASTM D120 CLASS 3 TYPE 1	26.5kV
4 (Orange)	40kV	70kV	10 W.H. Salisbury & Co. ANSI/ASTM D120 CLASS 4 TYPE 1	36kV

Glove Good News

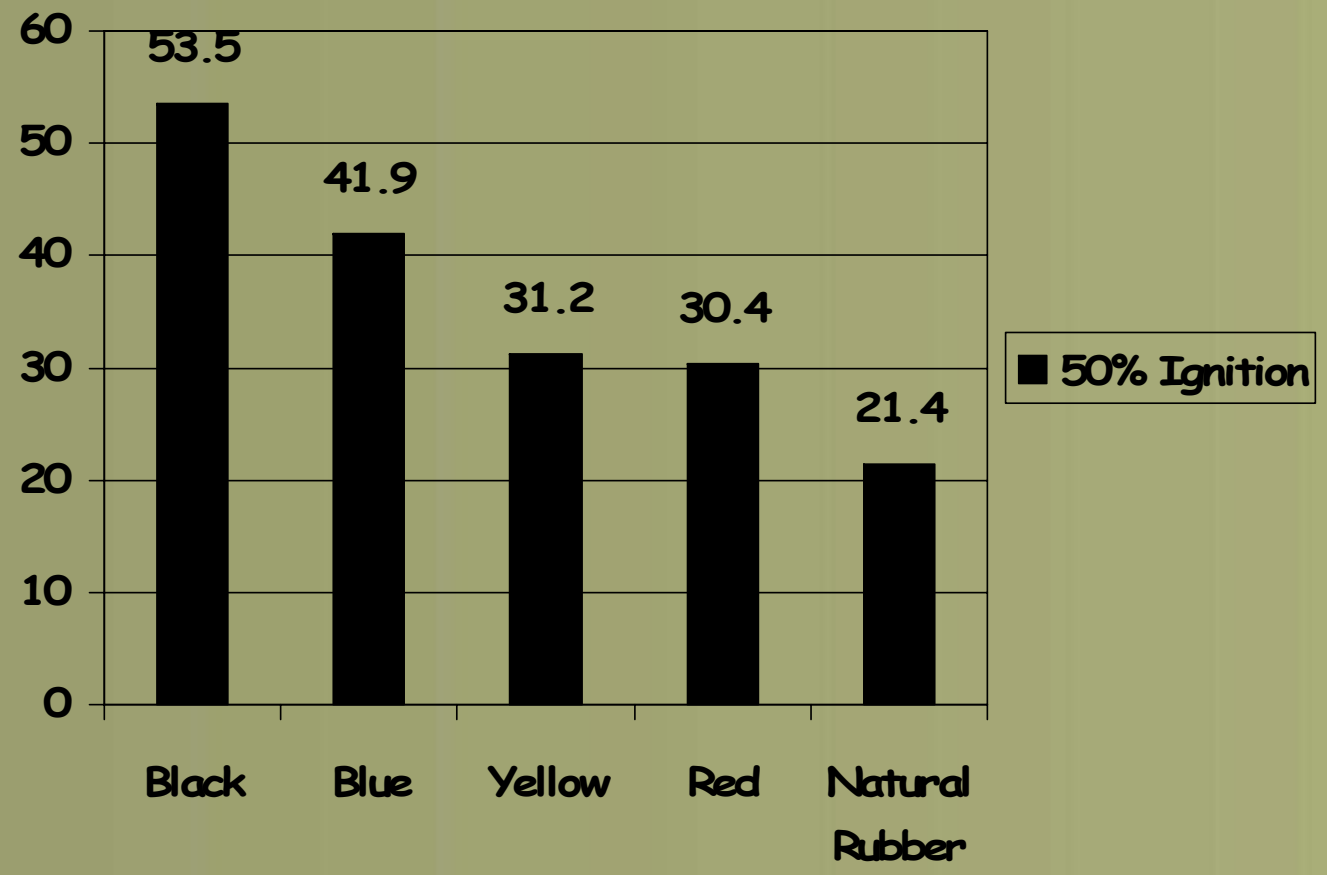
45 cal/cm²

ELECTRICAL
WORKPLACE SAFETY

Glove Limiting Factor: Ignition

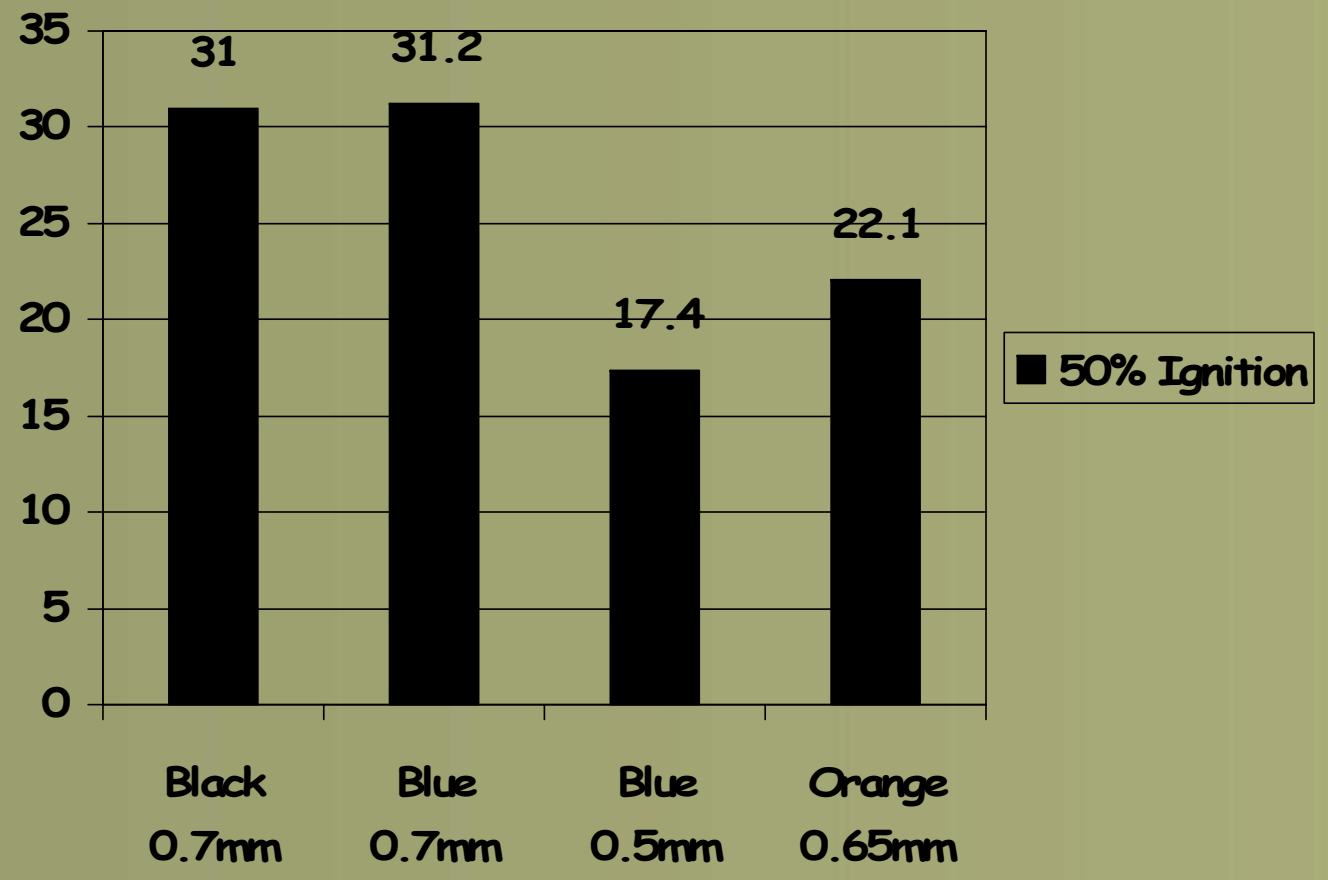
ELECTRICAL WORKPLACE SAFETY

Class 0 Rubber Glove Results (cal/cm²)



ELECTRICAL WORKPLACE SAFETY

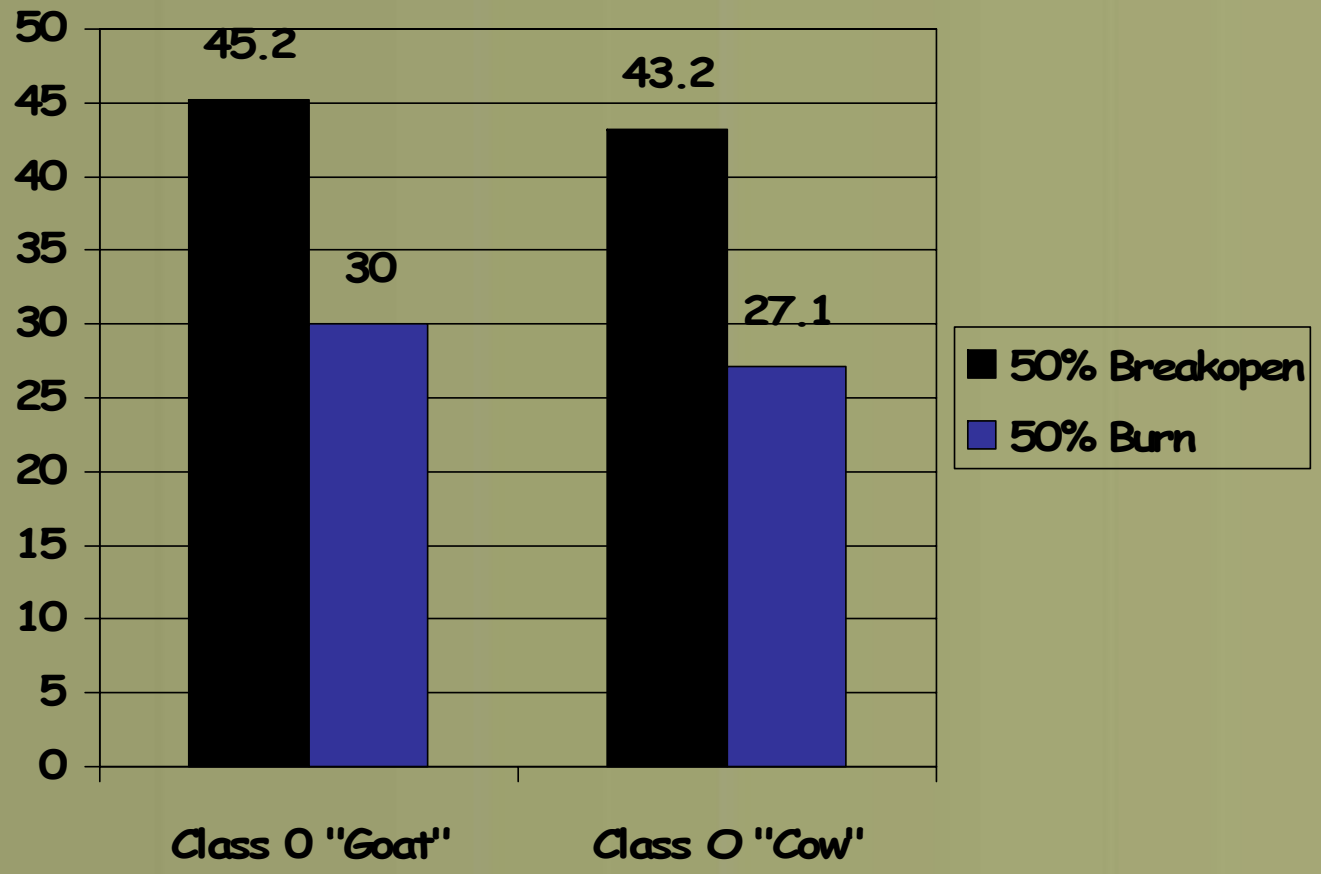
Class 00 Rubber Glove Results (cal/cm²)



PPE - Gloves

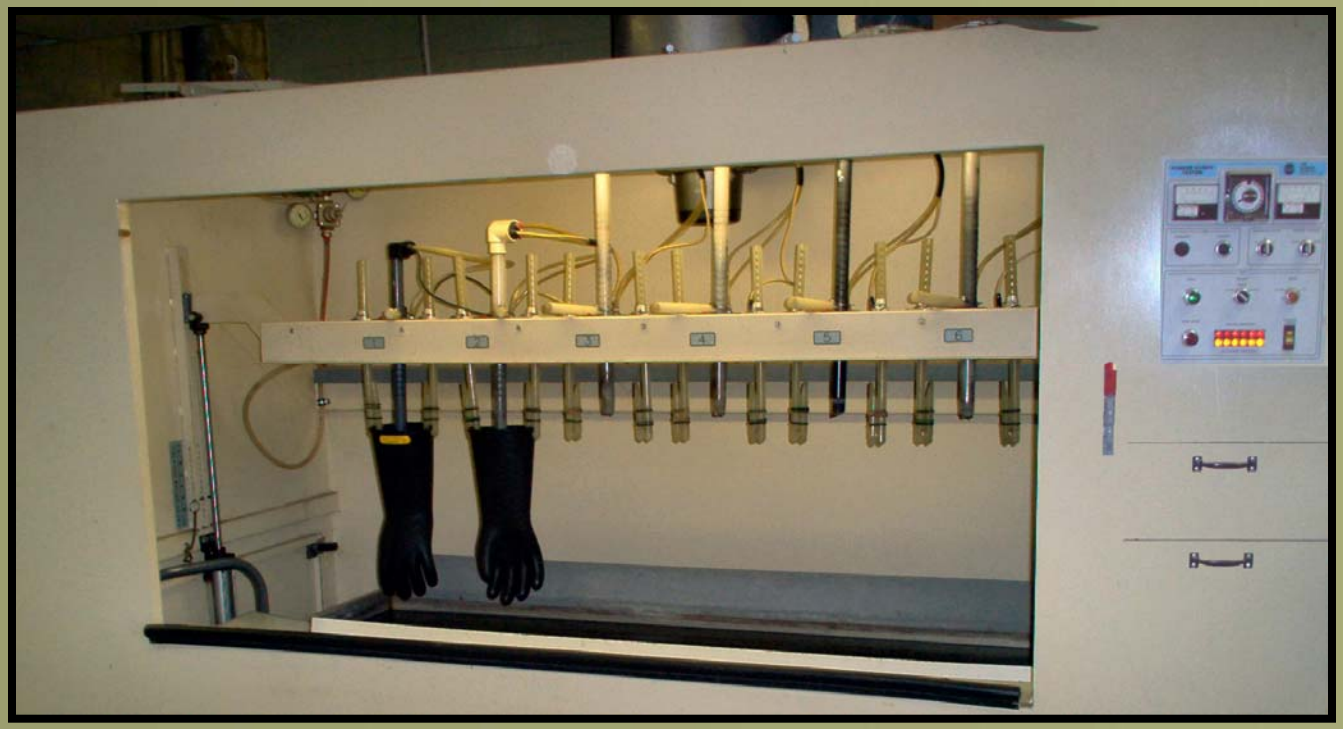
ELECTRICAL
WORKPLACE SAFETY

Leather Protector Results (cal/cm²)



Dielectric Testing of Gloves

Rubber gloves must be dielectrically tested before first use and then again every six months.



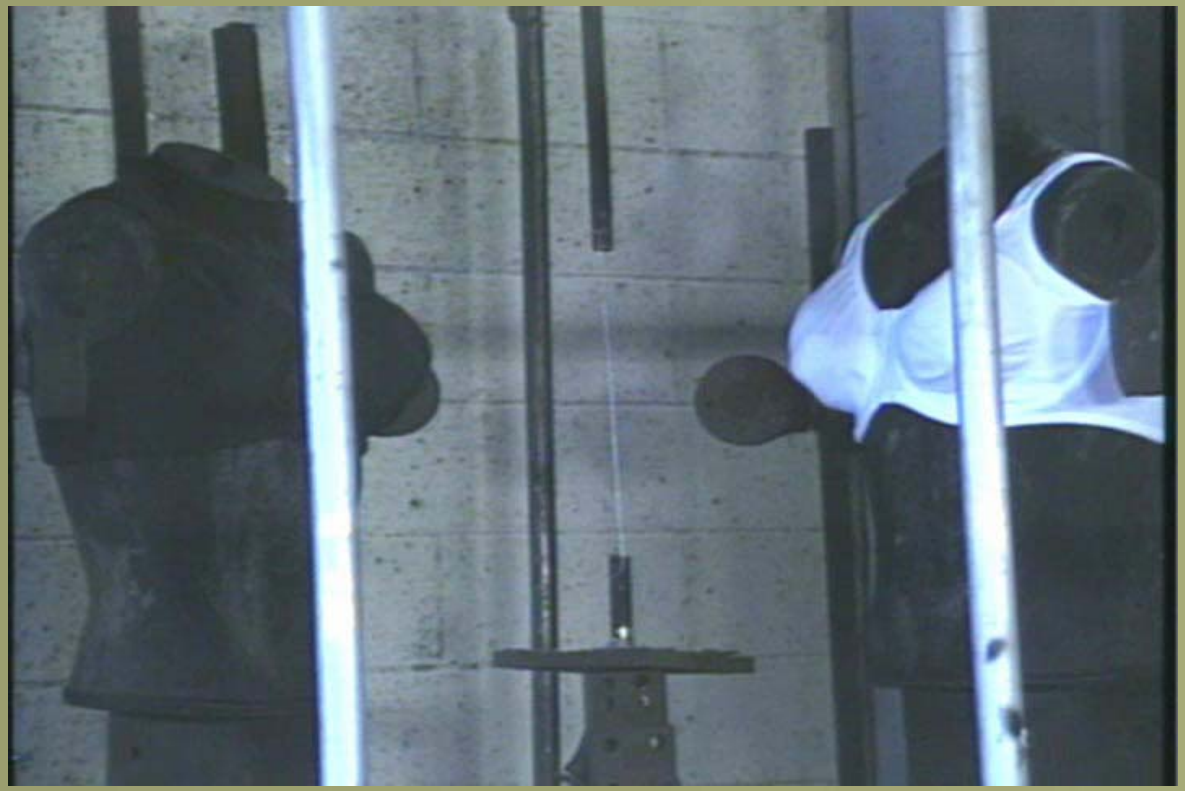
Using Non-FR Materials?

- Cotton
  - in underlayers when no breakopen risk
  - Still poses risk of ignition in tracking arc
- Wool
  - best in underlayers
- Silk
  - best in underlayers

25 cycles
FR options are available

ELECTRICAL
WORKPLACE SAFETY

Arc Resistant vs. Cotton Bra



ArcStore.com

The Underwear Question

- If outer layer does not breakopen or ignite, non-melting undergarments have tested well.
- Arc-resistant undergarments are available.

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Laundering can be critical

L: Clean R: 100 ml hydraulic oil

~20 cal/cm^2

Faceshields have limits

34 cal/cm²

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

The right PPE is vital

ELECTRICAL WORKPLACE SAFETY

Arc Flash Protection Principles

- Layering
  - Outer Layers
  - Under layers (non-melting or FR)
- Coverage
- Fit
- Maintenance of equipment
  - Laundering
    - Follow manufacturer's instructions
    - No chlorine bleach
    - No fabric softener
  - Inspect for tears and frays

Shirt Layering Data

- FR T-Shirts
  - Indura® UltraSoft® + FRC Knit 13.2 oz. ATPV=24.3 cal/cm²
  - 6.0 oz. Nomex®/6 oz. FR T-shirt ATPV=19.3 cal/cm²
- Non-FR T-Shirts
  - 4.6 oz PBI/Kevlar® 4.6 oz. Cotton ATPV= 14.5 cal/cm²
  - Nomex®/ 5 oz cotton t-shirt ATPV= 10 cal/cm²

Dangerous Clothing Characteristics

- Melting
- Flammability
- Clothing not permitted
  - Nylon, polyester, acetate or rayon
    - unless arc tested in blends

Will have graphic.

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Do not wear articles containing conductive material

Arc Resistant or FR?

Standard
Vertical Flame
Test
(ASTM D6413)

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

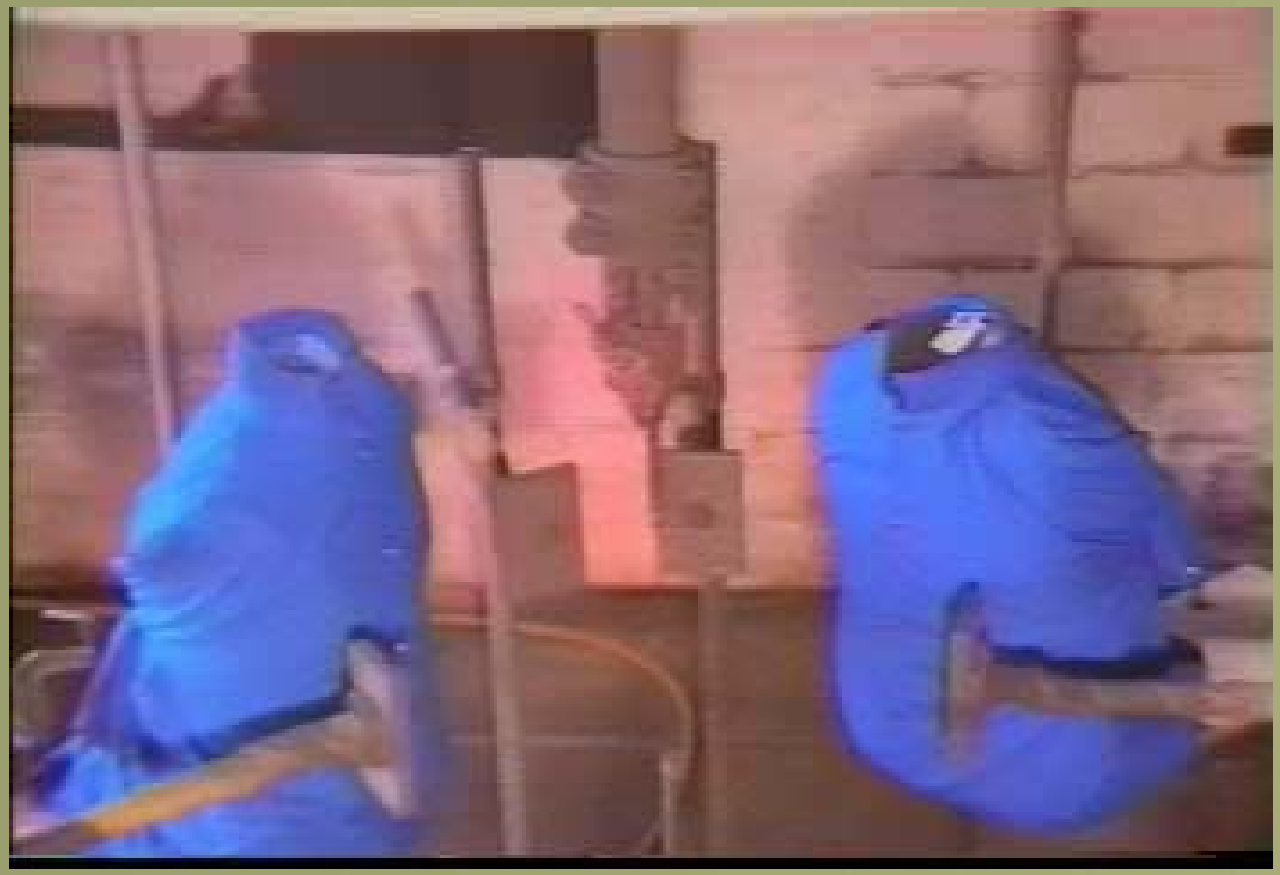
It may LOOK the same

ANSI 107 & F1506 vs. ANSI 107 "FR"

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

FR Clothing is not invincible.



Choose it for the application

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Disposable arc resistant materials for dirty applications

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Watch out for melting elastic

Watch out for melting “FR” accessories

- “FR” until washed or dry cleaned
- “FR” Melting always bad

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

See the “FR” melted onto the head?

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Non-FR Linings can get you burned in winter

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

EH Rated Shoes

Or

Dielectric Shoes

70E Does not Address this issue

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

OSHA 1910.269

(l)(6)(iii) The employer shall ensure that each employee who is exposed to the hazards of flames or electric arcs **does not wear clothing that**, when exposed to flames or electric arcs, **could increase the extent of injury** that would be sustained by the employee.

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Non-FR clothing can increase the extent of your injuries.

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

The level of potential or real risk will determine required PPE.

- PPE discussed here are minimum requirements
- PPE requirements may be more under certain circumstances.
  - Emergency
  - Unknown hazards
  - Unusual hazards

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Category 0 – Up to 1.2 cal/cm²

- Safety glasses
- Non-melting, flammable clothing with 4.5 oz/yd^2

- Safety glasses
- FR shirt & pants or coverall
- Hard hat

Category 1 – 1.2 to 4 cal/cm²

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Category 2 – 4.1 to 8 cal/cm²

- T-shirt
- Safety glasses
- FR shirt and pants or coveralls
- Hard hat
- Face shield or hood
- Hearing protection
- Gloves
- Leather work shoes

Category 3 – 8.1 to 25 cal/cm²

- Same as Level 2 plus coveralls
- Flash suit hood

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

Category 4 – 25.1 to 40 cal/cm²

- Same as Level 2 plus switcher's suit
- Flash suit hood

Over 40 cal/cm²

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

100% Cotton vs. HRC 2 Clothing

<20 cal/cm^2

Indura® UltraSoft® Shirt Indura® Denim Jean vs. Non-FR Cotton

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

HRC 4 Suit v. HRC 2

40 cal/cm² suit no 2° burn other 2 ° and 3 ° burns

PPE Standards

- Clothing
  - ASTM F1506
- Rainwear
  - ASTM F1891
- Hoods and Faceshields
  - ASTM F2178
- Fall Protection Exposed to Electric Arc
  - ASTM F887
- Gloves
  - ASTM D120

PPE – Preventing Injuries

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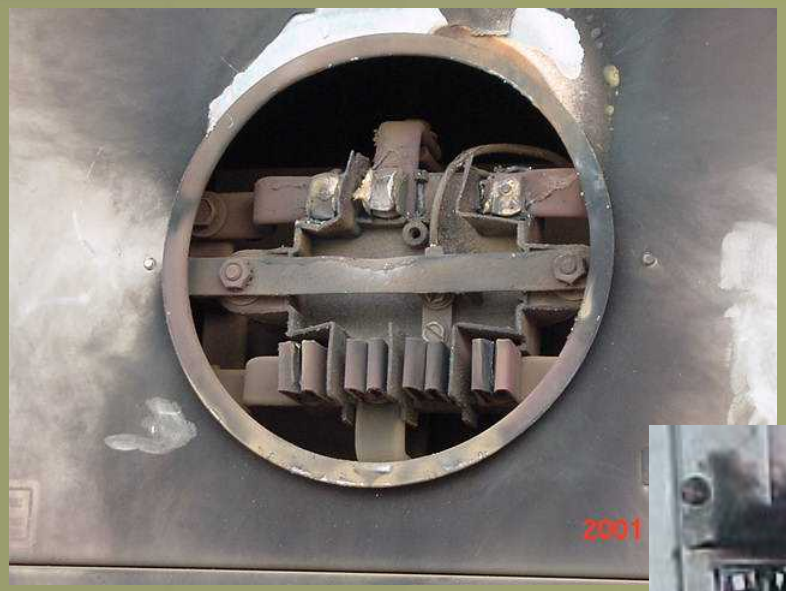
WORKPLACE SAFETY



Sometimes….

ELECTRICAL
WORKPLACE SAFETY

The only thing between you and this is...

Your PPE

PPE – Clothing

ELECTRICAL
WORKPLACE SAFETY

PPE is the last line of defense.

Before clothing is selected, arc hazards need to be reduced by:

- De-energizing equipment;
- Modifying equipment to reduce arc potential;
- Changing work rules to reduce or eliminate risk.

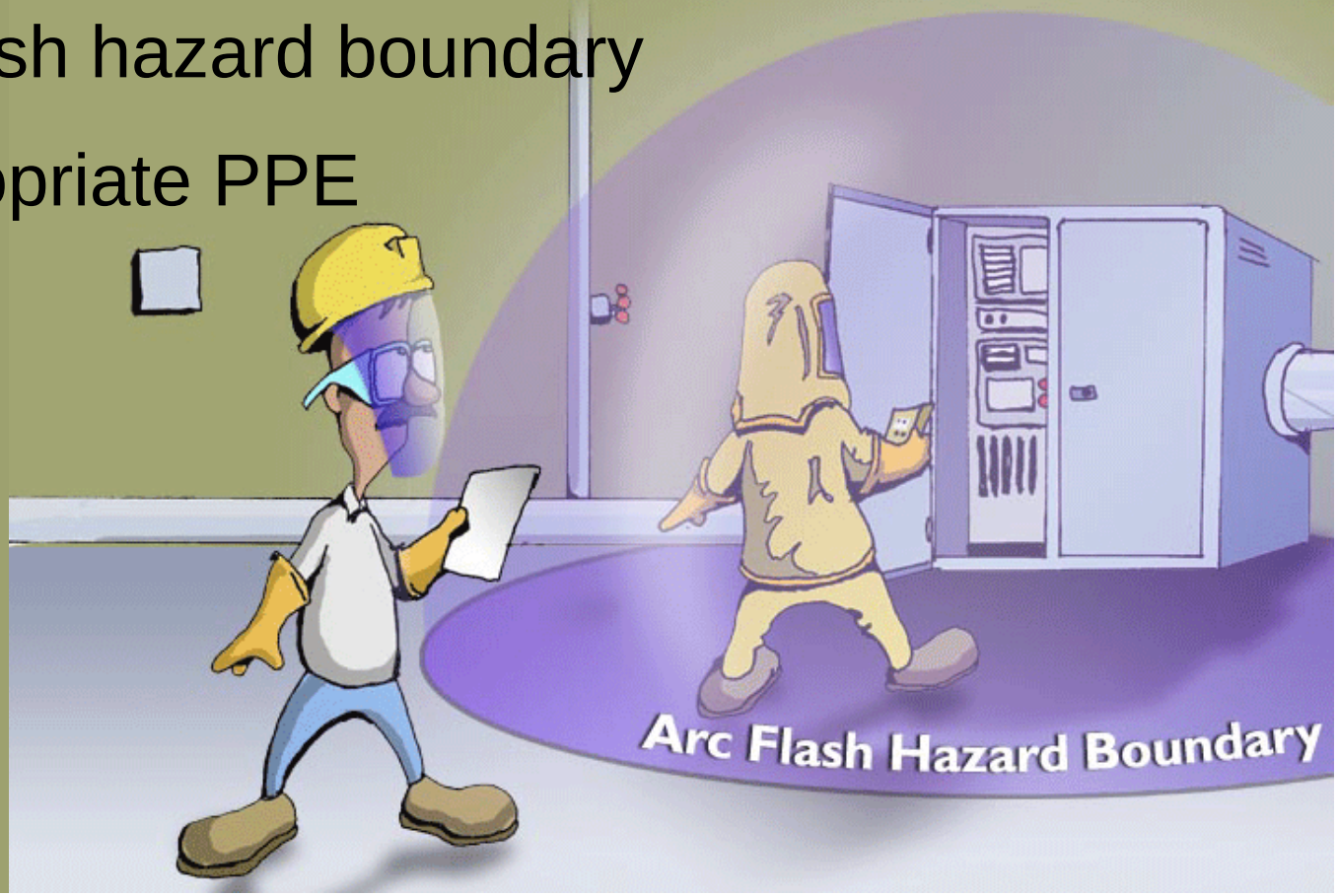
ELECTRICAL

Hazard Assessment

ELECTRICAL
WORKPLACE SAFETY

Hazard/Risk Analysis Musts

- Establish shock protection boundary
- Establish flash hazard boundary
- Select appropriate PPE

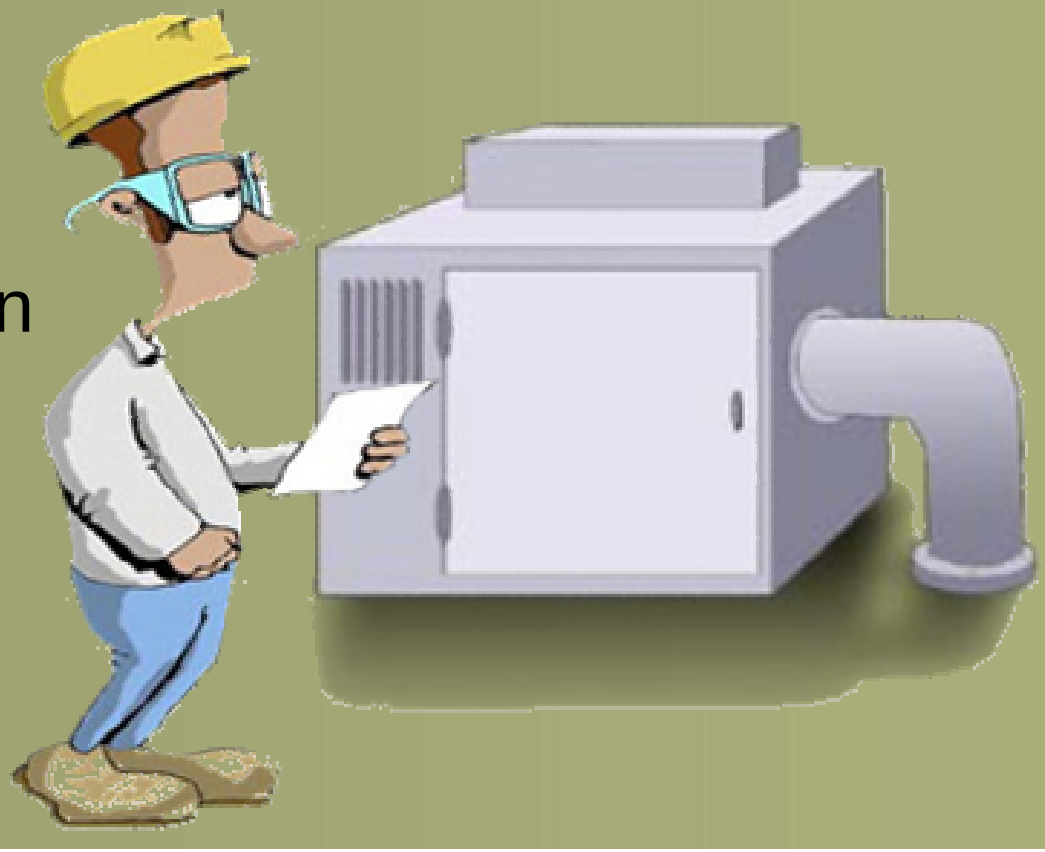


Arc Energy Theory

- Current available (amps ground fault or phase-to-phase)
- Duration of arc (cycles)
- Length of the arc (~6” max 480V)
- Distance from the arc (s^2)
- Arc voltage (70A-20kA arc voltage = 400-425V Westinghouse Protective Relay Book)
- Arc directionality (2-12X arc-in-a-box)

Determining distance boundaries

- May use table if meeting table note criteria
- May calculate
- May use combination of the two



ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist

Scenario One

Date: *7/23/04* Job Location: *Our Plant*

Equipment: *240V 3-Phase Panel Board replace CB*

Yes	No	
[X]	[ ]	1. Is the equipment operating at more than 50 volts or is a shock hazard present? If “yes,” perform a hazard/risk analysis. If “no,” coordinate with the Electrical Safety Program.
[ ]	[ ]	2. Is a flash hazard analysis required? (See NFPA 70E, 130.3)
[ ]	[ ]	3. Determine from NFPA 70E, Table 130.2(C):

a) Limited Approach Boundary

b) Restricted Approach Boundary

c) Prohibited Approach Boundary

Hazard Assessment

ELECTRICAL
WORKPLACE SAFETY

- **130.3 Flash Hazard Analysis.** A flash hazard analysis ***shall*** be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use.

ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist *Scenario One*

Date: *7/23/04* Job Location: *Our Plant*

Equipment: *240V 3-Phase Panel Board replace CB*

Yes	No	
[X]	[ ]	1. Is the equipment operating at more than 50 volts or is a shock hazard present? If “yes,” perform a hazard/risk analysis. If “no,” coordinate with the Electrical Safety Program.
[X]	[ ]	2. Is a flash hazard analysis required? (See NFPA 70E, 130.3)
		3. Determine from NFPA 70E, Table 130.2(C):
		a) Limited Approach Boundary
		b) Restricted Approach Boundary
		c) Prohibited Approach Boundary

Hazard Assessment

ELECTRICAL
WORKPLACE SAFETY

Table 130.2(C) Approach Boundaries to Live Parts for Shock Protection. (All dimensions are distance from live part to employee.)

(1)	(2) Limited Approach Boundary[1]	(3)	(4)	(5)
Nominal System Voltage Range, Phase to Phase	Exposed Movable Conductor	Exposed Fixed Circuit Part	Restricted Approach Boundary[1]; Includes Inadvertent Movement Adder	Prohibited Approach Boundary[1]
Less than 50	Not specified	Not specified	Not specified	Not specified
50 to 300	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	Avoid contact	Avoid contact
301 to 750	3.05 m (10 ft 0 in.)	1.07 m (3 ft 6 in.)	304.8 mm (1 ft 0 in.)	25.4 mm (0 ft 1 in.)
751 to 15 kV	3.05 m (10 ft 0 in.)	1.53 m (5 ft 0 in.)	660.4 mm (2 ft 2 in.)	177.8 mm (0 ft 7 in.)
15.1 kV to 36 kV	3.05 m (10 ft 0 in.)	1.83 m (6 ft 0 in.)	787.4 mm (2 ft 7 in.)	254 mm (0 ft 10 in.)
36.1 kV to 46 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	838.2 mm (2 ft 9 in.)	431.8 mm (1 ft 5 in.)
46.1 kV to 72.5 kV	3.05 m (10 ft 0 in.)	2.44 m (8 ft 0 in.)	965.2 mm (3 ft 2 in.)	635 mm (2 ft 1 in.)
72.6 kV to 121 kV	3.25 m (10 ft 8 in.)	2.44 m (8 ft 0 in.)	991 mm (3 ft 3 in.)	812.8 mm (2 ft 8 in.)
138 kV to 145 kV	3.36 m (11 ft 0 in.)	3.05 m (10 ft 0 in.)	1.093 m (3 ft 7 in.)	939.8 mm (3 ft 1 in.)
161 kV to 169 kV	3.56 m (11 ft 8 in.)	3.56 m (11 ft 8 in.)	1.22 m (4 ft 0 in.)	1.07 m (3 ft 6 in.)
230 kV to 242 kV	3.97 m (13 ft 0 in.)	3.97 m (13 ft 0 in.)	1.6 m (5 ft 3 in.)	1.45 m (4 ft 9 in.)
345 kV to 362 kV	4.68 m (15 ft 4 in.)	4.68 m (15 ft 4 in.)	2.59 m (8 ft 6 in.)	2.44 m (8 ft 0 in.)
500 kV to 550 kV	5.8 m (19 ft 0 in.)	5.8 m (19 ft 0 in.)	3.43 m (11 ft 3 in.)	3.28 m (10 ft 9 in.)
765 kV to 800 kV	7.24 m (23 ft 9 in.)	7.24 m (23 ft 9 in.)	4.55 m (14 ft 11 in.)	4.4 m (14 ft 5 in.)

Note: For Flash Protection Boundary, see 130.3(A).

[1]See definition in Article 100 and text in 130.2(D)(2) and Annex C for elaboration.

ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist *Scenario One*

Date: *7/23/04* Job Location: *Our Plant*

Equipment: *240V 3-Phase Panel Board replace CB*

Yes	No	
[X]	[ ]	1. Is the equipment operating at more than 50 volts or is a shock hazard present? If "yes," perform a hazard/risk analysis. If "no," coordinate with the Electrical Safety Program.
[X]	[ ]	2. Is a flash hazard analysis required? (See NFPA 70E, 130.3)
		3. Determine from NFPA 70E, Table 130.2(C):

a) Limited Approach Boundary ***3' 6" or 42"***

b) Restricted Approach Boundary ***Avoid Contact***

c) Prohibited Approach Boundary ***Avoid Contact***

Task Assessment Checklist, con't *Scenario One*

Yes	No	
[X]	[ ]	4. Determine the flash protection boundary from NFPA 70E, 130.3 (A).
[ ]	[ ]	5. Select the hazard/risk category for the task from NFPA 70E Table 130.7(C)(9)(a).
[ ]	[ ]	6. Is the fault energy level available at the location equal to or less than the table notes? If "yes," the table is applicable and you may proceed. If "no," STOP and investigate further. An arc flash analysis may be required.
[ ]	[ ]	7. Determine the need for voltage-rated tools and voltage-rated gloves.

Are voltage-rated tools required? Yes [ ] No [ ]

Are voltage-rated gloves required. Yes [ ] No [ ]

PPE Required:

Hazard Assessment

ELECTRICAL
WORKPLACE SAFETY

- **130.3 Flash Hazard Analysis.** A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use.
  (A) Flash Protection Boundary. ***For systems that are 600 volts or less, the Flash Protection Boundary shall be 4.0 ft,*** based on the product of clearing times of 6 cycles (0.1 second) and the available bolted fault current of 50 kA or any combination not exceeding 300 kA cycles (5000 ampere seconds).

ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist, con't

Yes	No	
[X]	[ ]	4. Determine the flash protection boundary from NFPA 70E, 130.3 (A). ***4 ft.***
[X]	[ ]	5. Select the hazard/risk category for the task from NFPA 70E Table 130.7(C)(9)(a).
[ ]	[ ]	6. Is the fault energy level available at the location equal to or less than the table notes? If "yes," the table is applicable and you may proceed. If "no," STOP and investigate further. An arc flash analysis may be required.
[ ]	[ ]	7. Determine the need for voltage-rated tools and voltage-rated gloves.

Are voltage-rated tools required? Yes [ ] No [ ]

Are voltage-rated gloves required. Yes [ ] No [ ]

PPE Required:

Hazard Assessment

ELECTRICAL
WORKPLACE SAFETY

Table 130.7(C)(9)(a) Hazard/Risk Category Classifications

Task (Assumes Equipment Is Energized, and Work Is Done Within the Flash Protection Boundary)	Hazard/ Risk Category	V-rated Gloves	V-rated Tools
Panelboards Rated 240 V and Below — Notes 1 and 3			
Circuit breaker (CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	0	N	N
Work on energized parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized parts)	1	N	N
Opening hinged covers (to expose bare, energized parts)	0	N	N
Panelboards or Switchboards Rated >240 V and up to 600 V (with molded case or insulated case circuit breakers) — Notes 1 and 3			
CB or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
600 V Class Motor Control Centers (MCCs) — Notes 2 (except as indicated) and 3			
CB or fused switch or starter operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch or starter operation with enclosure doors open	1	N	N

ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist, con't *Scenario One*

Yes	No	
[X]	[ ]	4. Determine the flash protection boundary from NFPA 70E, 130.3 (A). ***4 ft.***
[X]	[ ]	5. Select the hazard/risk category for the task from NFPA 70E Table 130.7(C)(9)(a). ***HRC 1***
[ ]	[ ]	6. Is the fault energy level available at the location equal to or less than the table notes? If "yes," the table is applicable and you may proceed. If "no," STOP and investigate further. An arc flash analysis may be required.
[ ]	[ ]	7. Determine the need for voltage-rated tools and voltage-rated gloves.

Are voltage-rated tools required? Yes [ ] No [ ]

Are voltage-rated gloves required. Yes [ ] No [ ]

PPE Required:

Hazard Assessment

ELECTRICAL
WORKPLACE SAFETY

Other Equipment 1 kV and Above			
Metal clad load interrupter switches, fused or unfused	—	—	—
Switch operation, doors closed	2	N	N
Work on energized parts, including voltage testing	4	Y	Y
Removal of bolted covers (to expose bare, energized parts)	4	N	N
Opening hinged covers (to expose bare, energized parts)	3	N	N
Outdoor disconnect switch operation (hookstick operated)	3	Y	Y
Outdoor disconnect switch operation (gang-operated, from grade)	2	N	N
Insulated cable examination, in manhole or other confined space	4	Y	N
Insulated cable examination, in open area	2	Y	N

Note:

V-rated Gloves are gloves rated and tested for the maximum line-to-line voltage upon which work will be done.

V-rated Tools are tools rated and tested for the maximum line-to-line voltage upon which work will be done.

2* means that a double-layer switching hood and hearing protection are required for this task in addition to the other Hazard/Risk Category 2 requirements of Table 130.7(C)(10).

Y = yes (required)

N = no (not required)

Notes:

1. 25 kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
2. 65 kA short circuit current available, 0.03 second (2 cycle) fault clearing time.
3. For < 10 kA short circuit current available, the hazard/risk category required may be reduced by one number.
4. 65 kA short circuit current available, 0.33 second (20 cycle) fault clearing time.
5. 65 kA short circuit current available, up to 1.0 second (60 cycle) fault clearing time.
6. For < 25 kA short circuit current available, the hazard/risk category required may be reduced by one number.

ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist, con't *Scenario One*

Yes	No	
[X]	[ ]	4. Determine the flash protection boundary from NFPA 70E, 130.3 (A). ***4 ft.***
[X]	[ ]	5. Select the hazard/risk category for the task from NFPA 70E Table 130.7(C)(9)(a). ***HRC 1***
[X]	[ ]	6. Is the fault energy level available at the location equal to or less than the table notes? If "yes," the table is applicable and you may proceed. If "no," STOP and investigate further. An arc flash analysis may be required.
[ ]	[ ]	7. Determine the need for voltage-rated tools and voltage-rated gloves.

Are voltage-rated tools required? Yes [ ] No [ ]

Are voltage-rated gloves required. Yes [ ] No [ ]

PPE Required:

Hazard Assessment

ELECTRICAL
WORKPLACE SAFETY

Table 130.7(C)(9)(a) Hazard/Risk Category Classifications

Task (Assumes Equipment Is Energized, and Work Is Done Within the Flash Protection Boundary)	Hazard/ Risk Category	V-rated Gloves	V-rated Tools
Panelboards Rated 240 V and Below — Notes 1 and 3			
Circuit breaker (CB) or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	0	N	N
Work on energized parts, including voltage testing	1	Y	Y
Remove/install CBs or fused switches	1	Y	Y
Removal of bolted covers (to expose bare, energized parts)	1	N	N
Opening hinged covers (to expose bare, energized parts)	0	N	N
Panelboards or Switchboards Rated >240 V and up to 600 V (with molded case or insulated case circuit breakers) — Notes 1 and 3			
CB or fused switch operation with covers on	0	N	N
CB or fused switch operation with covers off	1	N	N
Work on energized parts, including voltage testing	2*	Y	Y
600 V Class Motor Control Centers (MCCs) — Notes 2 (except as indicated) and 3			
CB or fused switch or starter operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused switch or starter operation with enclosure doors open	1	N	N

ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist, con't

Yes	No	
[X]	[ ]	4. Determine the flash protection boundary from NFPA 70E, 130.3 (A). ***4 ft.***
[X]	[ ]	5. Select the hazard/risk category for the task from NFPA 70E Table 130.7(C)(9)(a). ***HRC 1***
[X]	[ ]	6. Is the fault energy level available at the location equal to or less than the table notes? If "yes," the table is applicable and you may proceed. If "no," STOP and investigate further. An arc flash analysis may be required.
[X]	[ ]	7. Determine the need for voltage-rated tools and voltage-rated gloves.

Are voltage-rated tools required? Yes [X] No [ ]

Are voltage-rated gloves required. Yes [X] No [ ]

PPE Required:

Hazard Assessment

ELECTRICAL WORKPLACE SAFETY

Table 130.7(C)(10) Protective Clothing and Personal Protective Equipment (PPE) Matrix

Protective Clothing and Equipment	Protective Systems for Hazard/Risk Category					
Hazard/Risk Category Number	–1 (Note 3)	0	1	2	3	4
Non-melting (according to ASTM F 1506-00) or Untreated Natural Fiber						
a. T-shirt (short-sleeve)	X			X	X	X
b. Shirt (long-sleeve)		X				
c. Pants (long)	X	X	X (Note 4)	X (Note 6)	X	X
FR Clothing (Note 1)						
a. Long-sleeve shirt			X	X	X (Note 9)	X
b. Pants			X (Note 4)	X (Note 6)	X (Note 9)	X
c. Coverall			(Note 5)	(Note 7)	X (Note 9)	(Note 5)
d. Jacket, parka, or rainwear			AN	AN	AN	AN
FR Protective Equipment						
a. Flash suit jacket (multilayer)						X
b. Flash suit pants (multilayer)						X
c. Head protection						
1. Hard hat			X	X	X	X
2. FR hard hat liner					AR	AR
d. Eye protection		—	—	—	—	—
1. Safety glasses	X	X	X	AL	AL	AL
2. Safety goggles				AL	AL	AL
e. Face and head area protection		—	—	—	—	—

ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist, con't *Scenario One*

Yes	No	
[X]	[ ]	4. Determine the flash protection boundary from NFPA 70E, 130.3 (A). ***4 ft.***
[X]	[ ]	5. Select the hazard/risk category for the task from NFPA 70E Table 130.7(C)(9)(a). ***HRC 1***
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Are voltage-rated tools required? Yes [X] No [ ]

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ELECTRICAL WORKPLACE SAFETY

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a. T-shirt (short-sleeve)	X			X	X	X
b. Shirt (long-sleeve)		X				
c. Pants (long)	X	X	X (Note 4)	X (Note 6)	X	X
FR Clothing (Note 1)						
a. Long-sleeve shirt			X	X	X (Note 9)	X
b. Pants			X (Note 4)	X (Note 6)	X (Note 9)	X
c. Coverall			(Note 5)	(Note 7)	X (Note 9)	(Note 5)
d. Jacket, parka, or rainwear			AN	AN	AN	AN
FR Protective Equipment						
a. Flash suit jacket (multilayer)						X
b. Flash suit pants (multilayer)						X
c. Head protection						
1. Hard hat			X	X	X	X
2. FR hard hat liner					AR	AR
d. Eye protection		—	—	—	—	—
1. Safety glasses	X	X	X	AL	AL	AL
2. Safety goggles				AL	AL	AL
e. Face and head area protection		—	—	—	—	—

ELECTRICAL WORKPLACE SAFETY

Task Assessment Checklist, con't *Scenario One*

Yes	No	
[X]	[ ]	4. Determine the flash protection boundary from NFPA 70E, 130.3 (A). ***4 ft.***
[X]	[ ]	5. Select the hazard/risk category for the task from NFPA 70E Table 130.7(C)(9)(a). ***HRC 1***
[X]	[ ]	6. Is the fault energy level available at the location equal to or less than the table notes? If "yes," the table is applicable and you may proceed. If "no," STOP and investigate further. An arc flash analysis may be required.
[X]	[ ]	7. Determine the need for voltage-rated tools and voltage-rated gloves.

Are voltage-rated tools required? Yes [X] No [ ]

Are voltage-rated gloves required. Yes [X] No [ ]

PPE Required: ***Denim Jeans or 4 cal/cm² pant, Long-sleeved 4 cal/cm² shirt, Class O Rubber gloves or Class OO Rubber Gloves and Leather Protectors, Hard Hat and Safety Glasses, Optional FR winterwear and leather shoes.***

ELECTRICAL
WORKPLACE SAFETY

Arc Hazard Energy Changes

At Substation

- 8000 Amps
- 12 in arc gap
- 12,500 system
- 12 in to worker
- 10 cycle duration
- 10 cal/cm^2

Secondary system

- 40,000 Amps
- 2 in arc gap
- 480 system
- 12 in to worker
- 20 cycle duration
- 30 cal/cm^2

100% Cotton Arc Data

ELECTRICAL
WORKPLACE SAFETY

- Data provided by OSHA (8kA) 10% ignition threshold
  - 5.2 oz. Blue Twill 4.6 cal/cm^2
  - 6.2 oz. White Fleece 6.4 cal/cm^2
  - 6.9 oz. Blue Twill 5.3 cal/cm^2
  - 8.0 oz. Black Twill 6.1 cal/cm^2
  - 8.3 oz. White Sateen 11.6 cal/cm^2
  - 11.9 oz. Tan Duck 11.3 cal/cm^2
  - 12.8 oz. Blue Denim 15.5 cal/cm^2
  - 13.3 oz. Blue Denim 15.9 cal/cm^2

Source “Testing Update on Protective Clothing & Equipment for Electric Arc Exposure” IEEE Paper No. PCIC-97-35.

ELECTRICAL

Safety-Related Work Practices

Your Pre-Work Briefing Responsibilities

Make sure you clearly understand the task, the procedures, and your responsibility.

Make sure you know all the following prior to beginning the task:

The details and scope of the task.

All hazards that may be present.

Your role and responsibilities during the task.

All applicable safety rules.

What PPE is needed to safely perform the task.

Ground Fault Circuit Interrupters

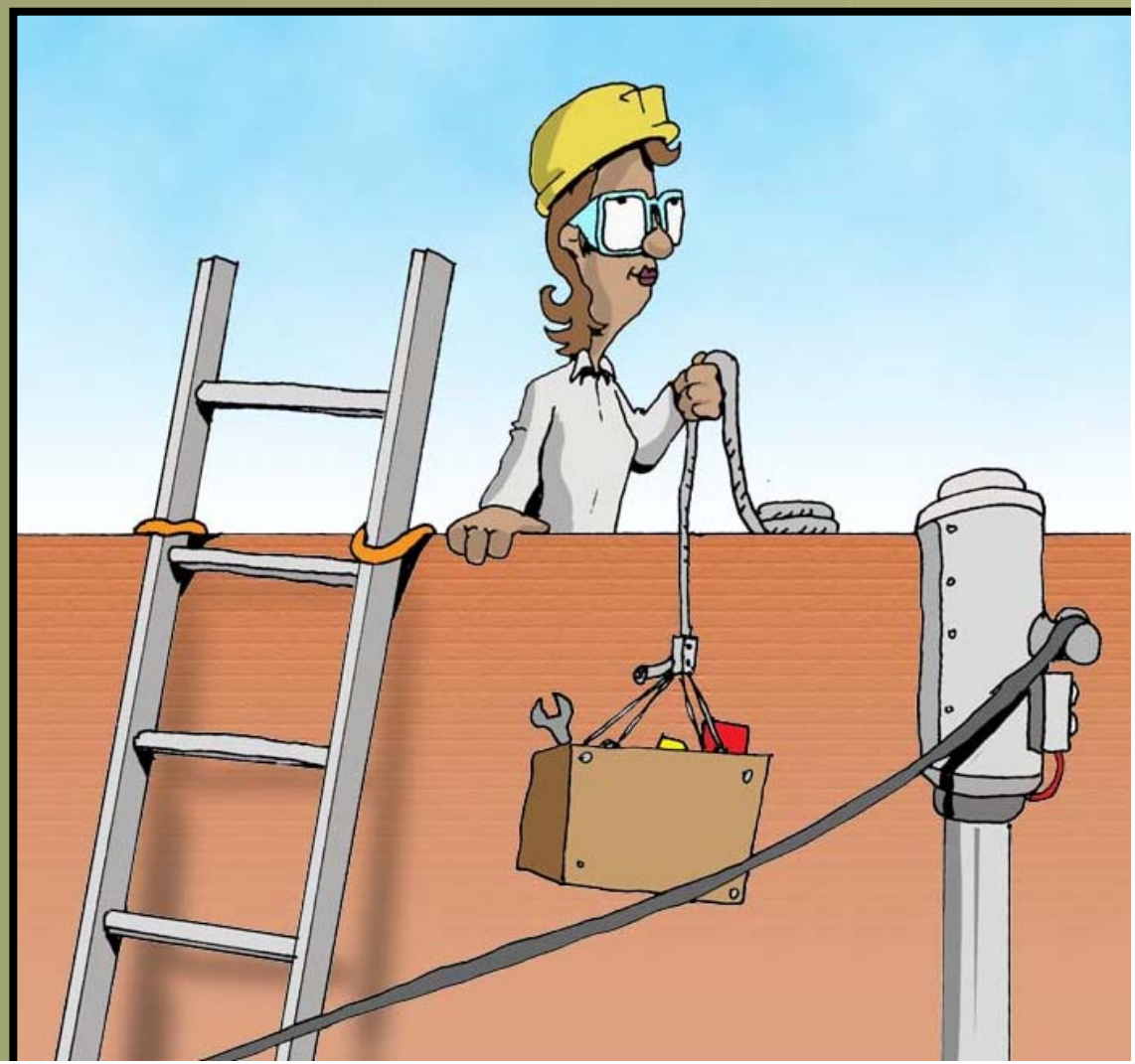
All portable electric tools must be and extension cords must be connected to a Ground Fault Circuit Interrupter (GFCI).

Mobile Equipment and the Limited Approach Boundary

- Keep mobile equipment at least 48” from energy sources <600 volts.
- See 70E Table 130.2(C) for higher voltage Limited Approach Boundary.
- If mobile equipment must enter the limited approach boundary, de-energize or insulate exposed, energized parts.

Working Overhead

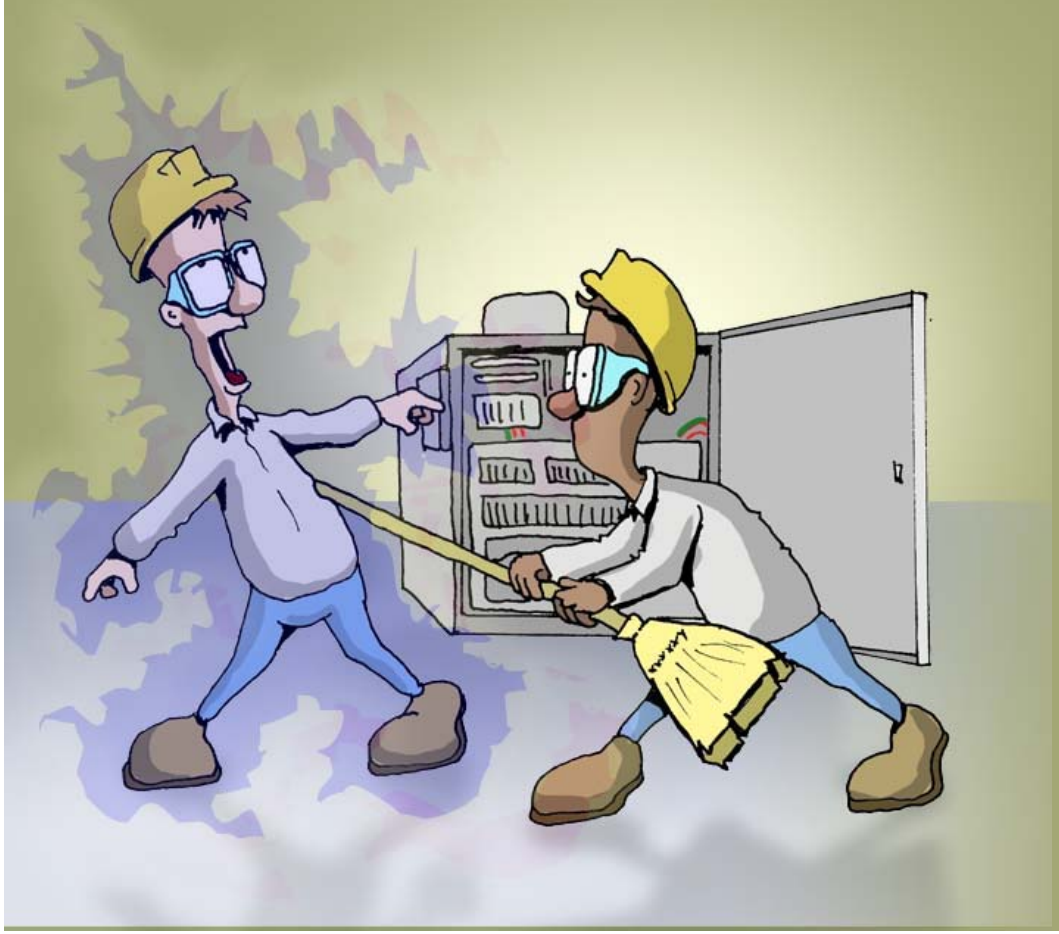
- Use non-conductive ladders.
- Raise and lower tools or materials with a non-conductive rope or handline.
- Watch out for persons below.



Flammable liquids and gases

Use EXTEME caution when using flammable materials around electrical equipment.

Helping someone getting shocked



Call for assistance if possible

Do not put yourself in danger

Assess the situation

Consider the voltage

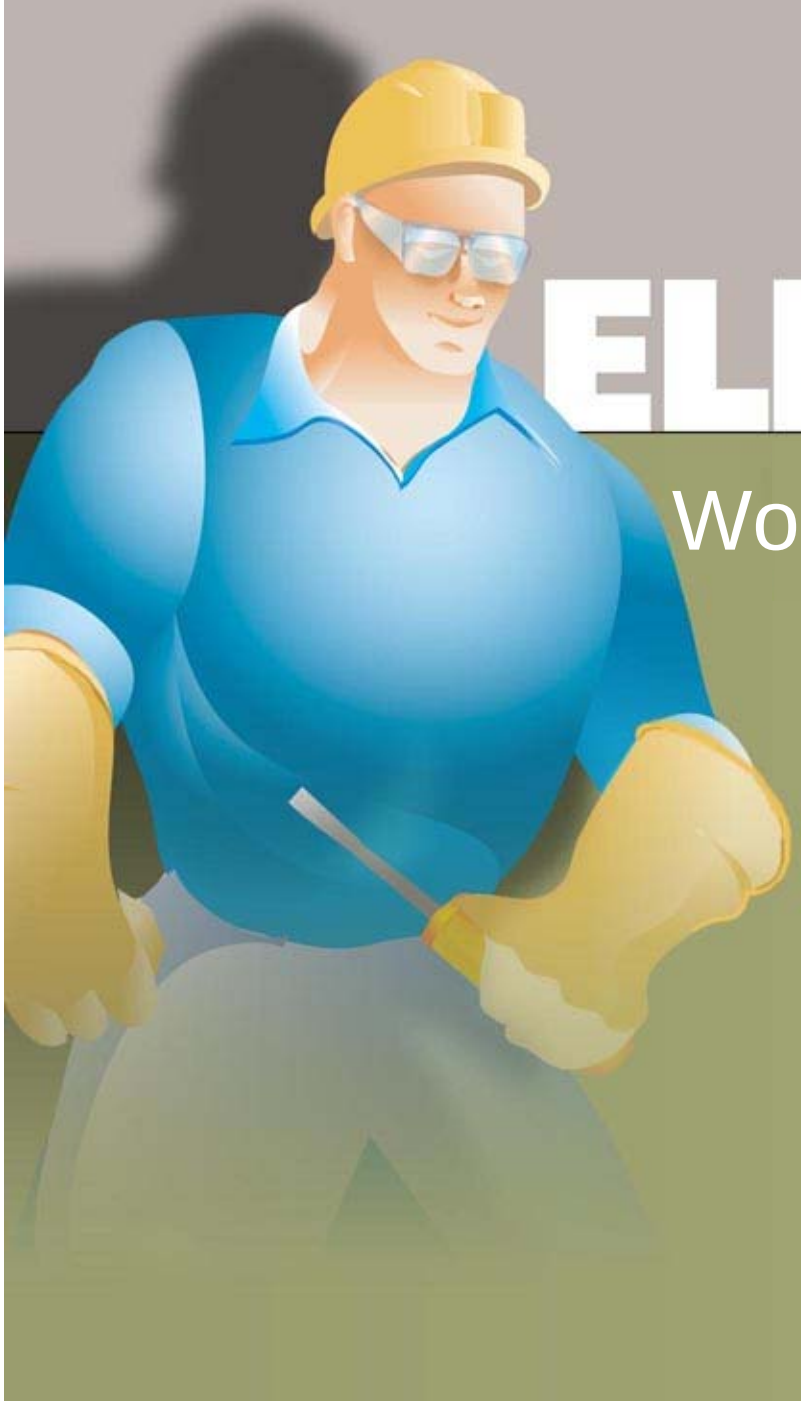
Use a non-conductive means to free them from the source

Record Keeping

- Records of training required by OSHA.
- Some incident records required.
- Electrical safety program plans and procedures must be in writing.
- Audit records required.

Auditing

- Audits are needed to do the following:
  - Prove procedures work.
  - Identify procedures that don't work.
  - Monitor workplace conditions.
  - Identify changes that should be made.
  - Identify retraining needs.
- Minimum annual audit to monitor safe work practices.



ELECTRICAL

Working On or Near Live Parts

Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

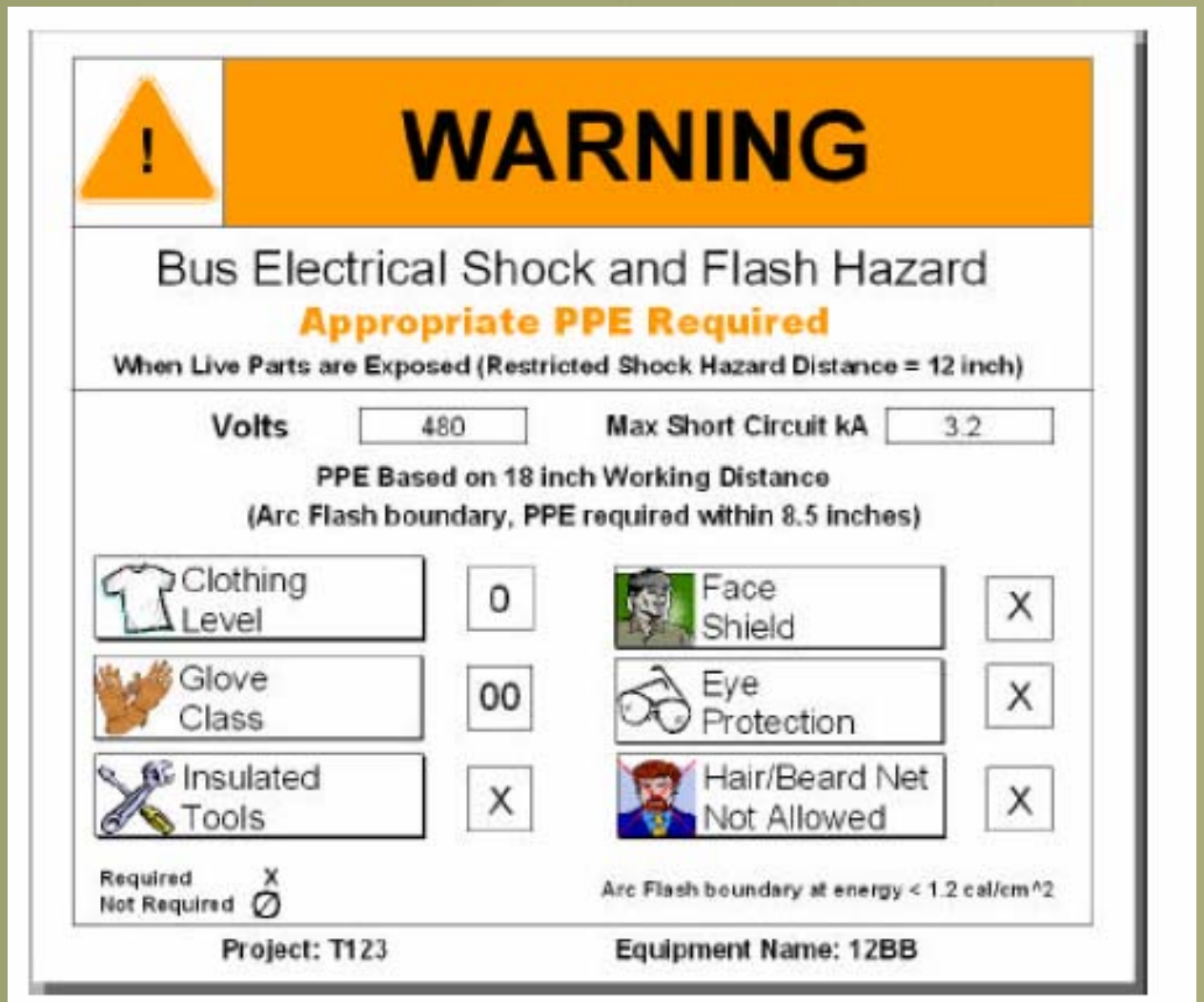
Working near live parts is defined as any activity inside a limited approach boundary.

Working inside the limited approach boundary requires shock and flash protection

Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

Proper PPE defined by an arc label



WARNING

Bus Electrical Shock and Flash Hazard

Appropriate PPE Required

When Live Parts are Exposed (Restricted Shock Hazard Distance = 12 inch)

Volts 480 Max Short Circuit kA 3.2

PPE Based on 18 inch Working Distance
(Arc Flash boundary, PPE required within 8.5 inches)

Clothing Level	0	Face Shield	X
Glove Class	00	Eye Protection	X
Insulated Tools	X	Hair/Beard Net Not Allowed	X

Required X
Not Required ∅

Arc Flash boundary at energy < 1.2 cal/cm^2

Project: T123 Equipment Name: 12BB

Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

- De-energize before anyone works on or near live parts.
- If infeasible to de-energize:
  - Increased hazard
  - Equipment design
  - Operational limitations
- Infeasible versus inconvenient.
- If below 50 volts, acceptable to work live.

NFPA 70E Requirements for Work on or near Live Parts

- Energized electrical work permit
- Hazard/risk analysis
- Personal protective equipment
- Training (qualified person)
- Job briefing

Working On or Near Live Parts

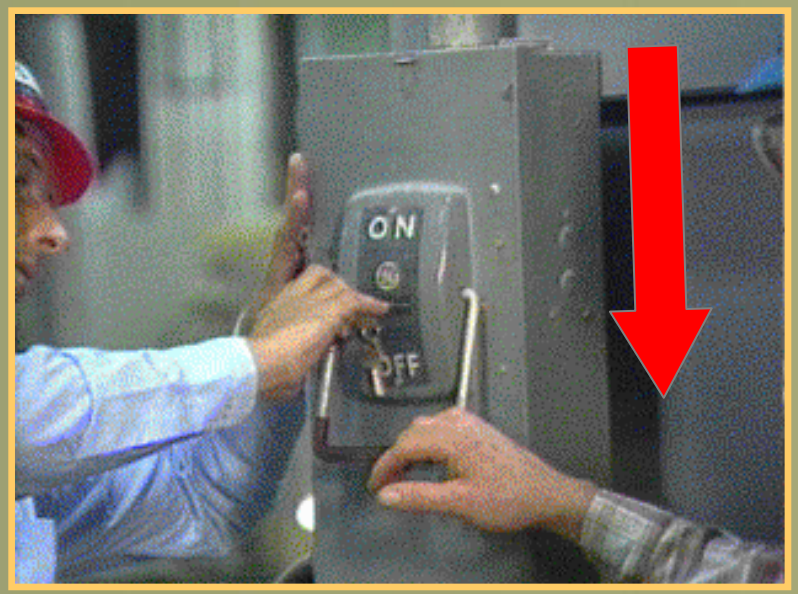
ELECTRICAL
WORKPLACE SAFETY

General Rules

- Always consider electrical equipment energized until locked, tagged and verified.
- Maintain the required approach boundary distances.
- Always create a safe working zone.

Isolate & Confirm

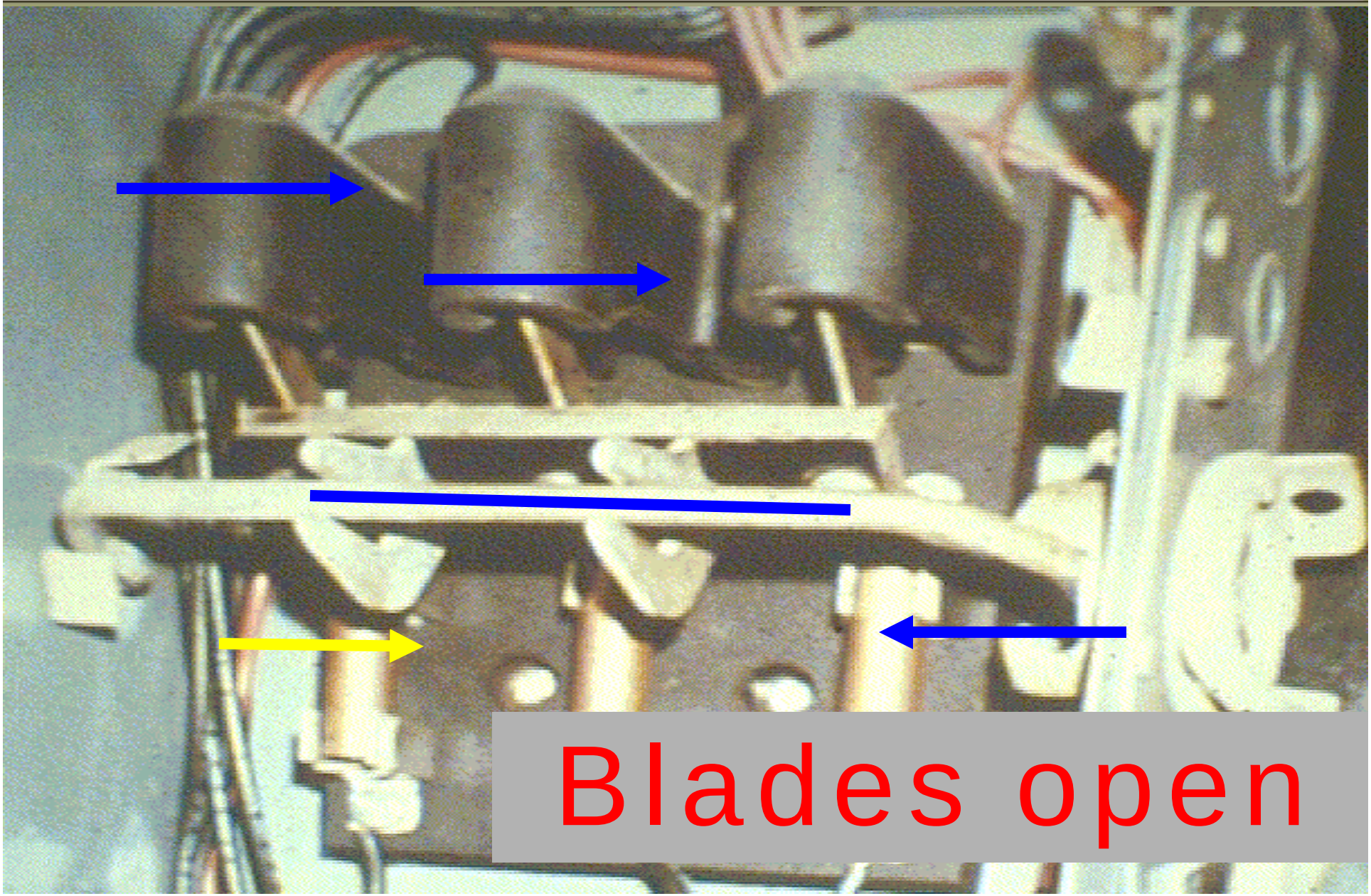
What is the one thing you know when you pull a disconnect down?



You moved the handle.

Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY



Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

"Left" Hand Rule

- Stand out of the "line-of-fire."
- Turn head away.
- Take a deep breath and hold it.

Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

Tag & Lock

Verify equipment is de-energized.

Test (verify) and Ground

Verify voltage detector works properly before and after test.

Use Proper Voltage Detector

All voltage testers are not equal

Fluke T5-1000 - one example of a recommended voltage and current tester

- Inherently self-protected (ohm setting)
- Checks DC and AC on a single voltage selection
- UL category III or IV device, depending on whether used on 1000v or 600v systems.

Wiggy not recommended.

Energized Electrical Work Permit

- Requires written authorization
- Requires the worker to do the following:
  - Identify and understand the hazards.
  - Be a qualified person.
  - Wear the proper PPE.
  - Restrict access to unqualified persons.
  - Complete a job briefing.

Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

Energized Electrical Work Permit

Annex J, Energized Electrical Work Permit

This annex is not a part of the requirements of this NFPA document, but is included for informational purposes only.

ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER:

Job/Work Order Number _____

1) Description of circuit/equipment/job location _____

2) Description of work to be done _____

3) Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage: _____

Requester/Title _____ Date _____

PART III: APPROVAL(s) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:

M _____ Maintenance Engineering Manager

Safety Manager _____ Electrically Knowledgeable Person _____

General Manager _____ Date _____

Note: Once the work is complete, forward this form to the site Safety Department for review and retention.

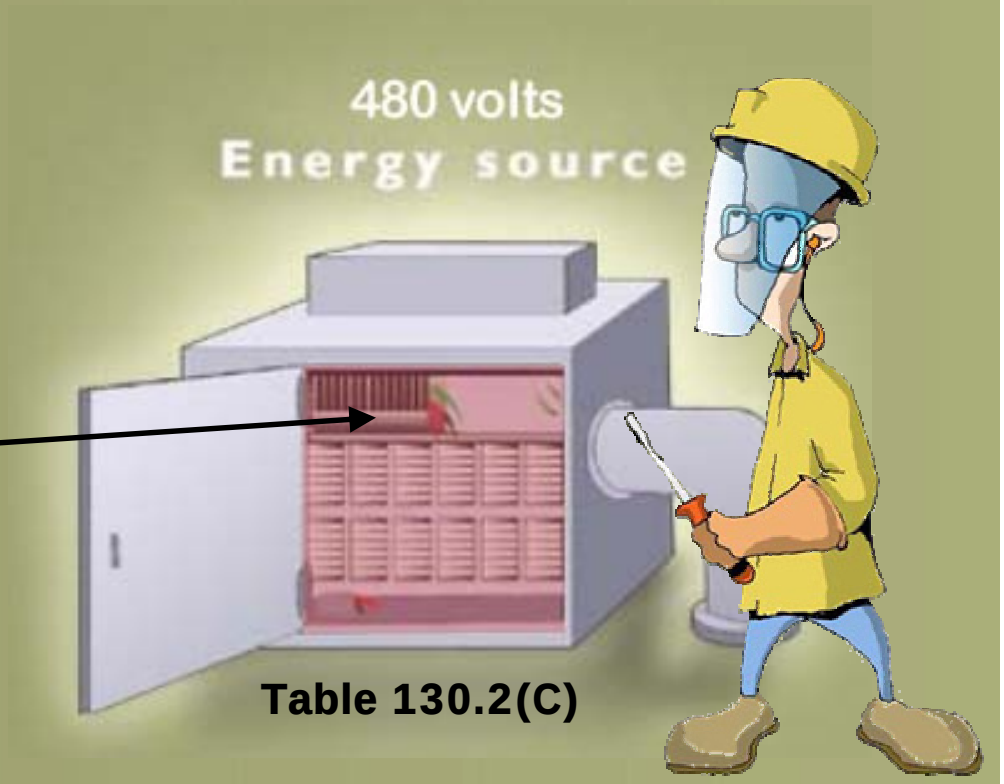
Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

If working inside the Prohibited Approach Boundary, you are performing live-line work.

Work permit required unless. . .

Prohibited (1 inch)



Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

No Permit Required for:

- Testing (voltage, current, phasing, & system tuning)
- Circuit identification
- Troubleshooting
- “Standing” work permits allowed if written and management approved

Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

Before exposing energized parts, identify and communicate the safe work zone (barricade)

Properly barricade work areas containing electrical hazards not normally encountered during routine work.

What else should be done to identify the safe work zone?

Barricading – Restrict Access to the Area

Use physical obstructions, such as tapes, ropes, cones, or A-frame type wood or metal structures, to provide warnings about a hazardous area.

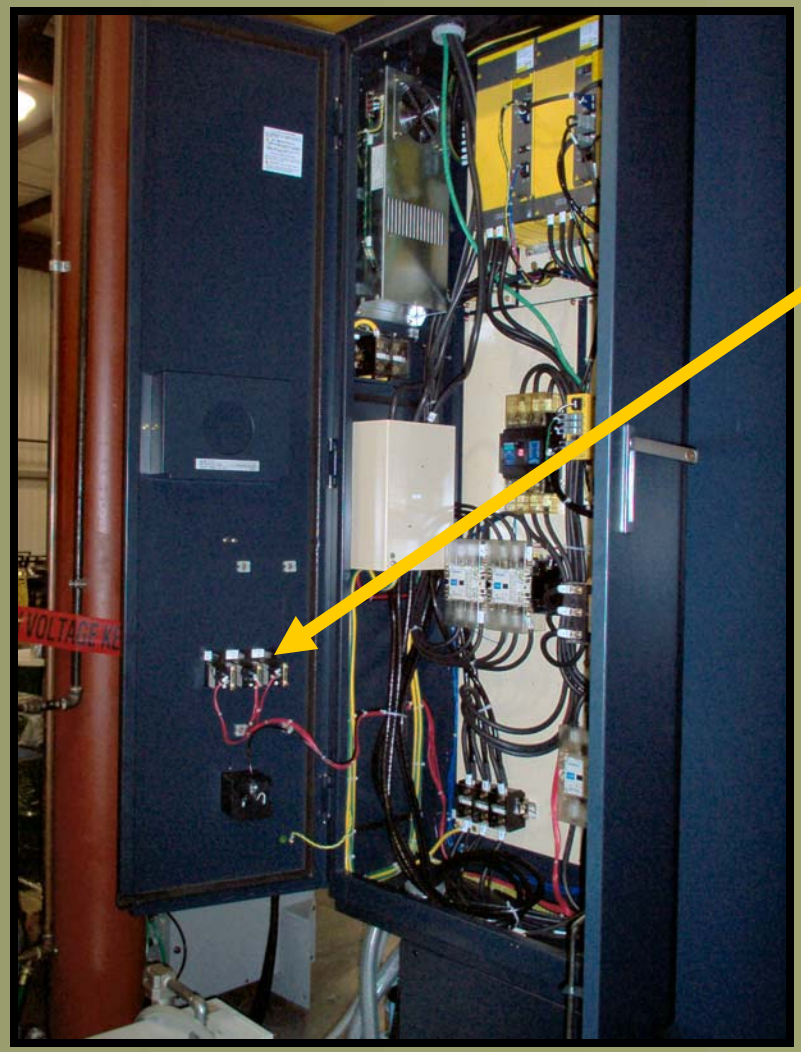
Barricades limit access to an area.

They are temporary and not to be used as permanent guarding.

Electrical Hazard Barricade Tape and Rope

Tape and rope should be red and imprinted with wording such as “Danger - Electrical Shock Hazard KEEP OUT”

Barricading - Identify the safe work zone

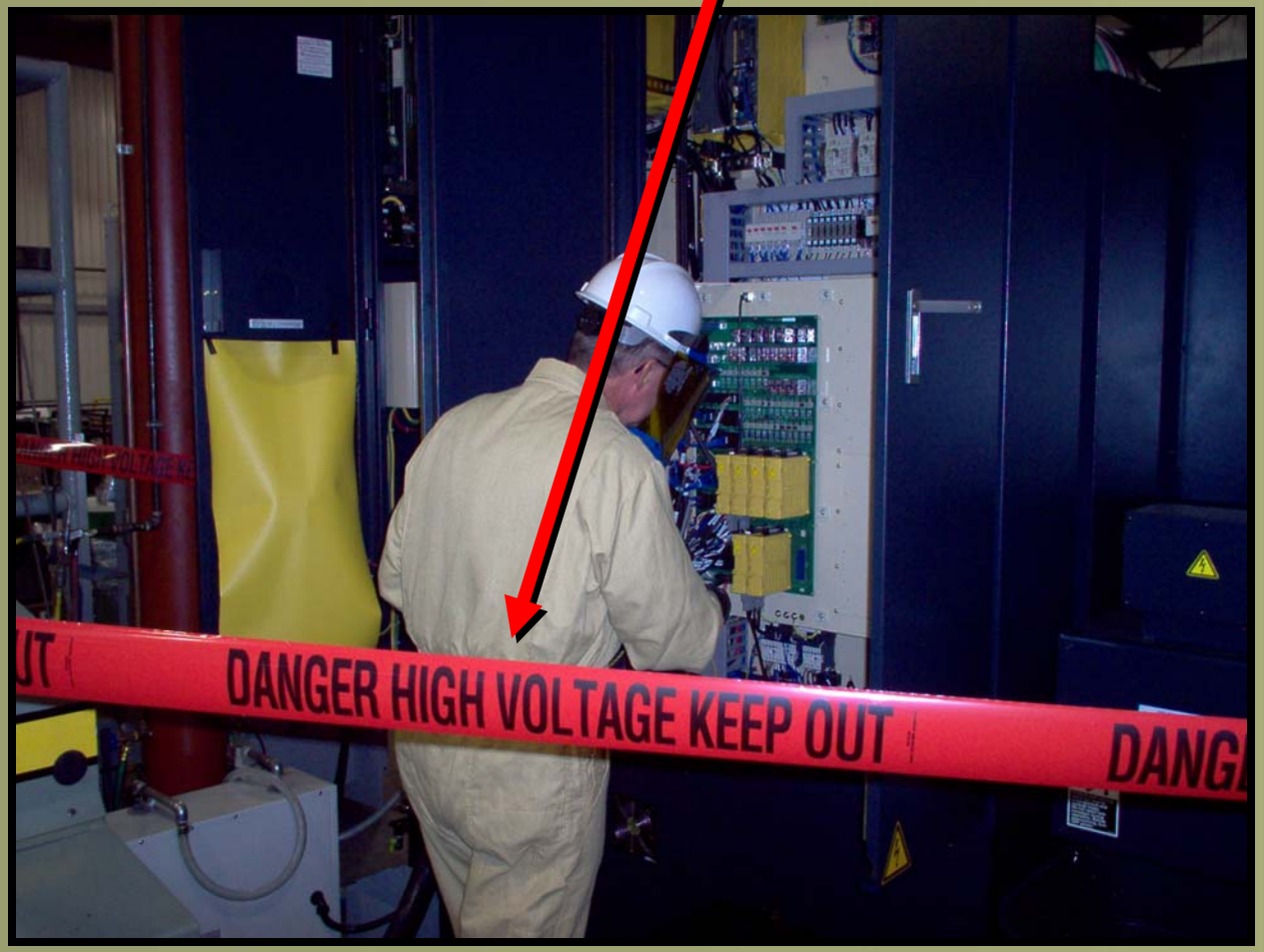


Shield persons working on equipment from exposed, energized parts.

Working On or Near Live Parts

ELECTRICAL
WORKPLACE SAFETY

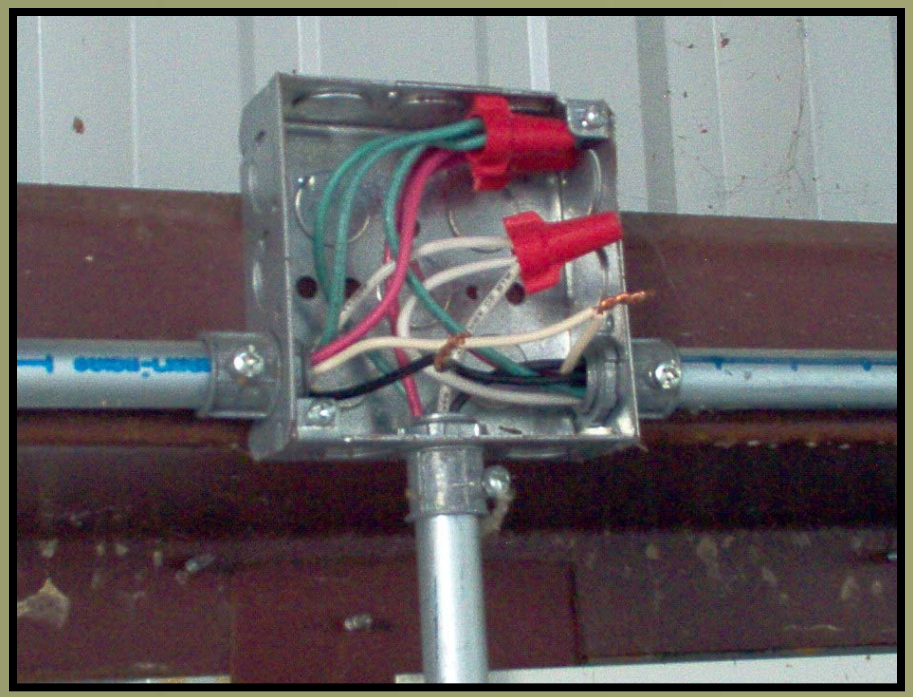
Tape and rope are *temporary* barricades *ONLY*.



ELECTRICAL
Be Safe Out There

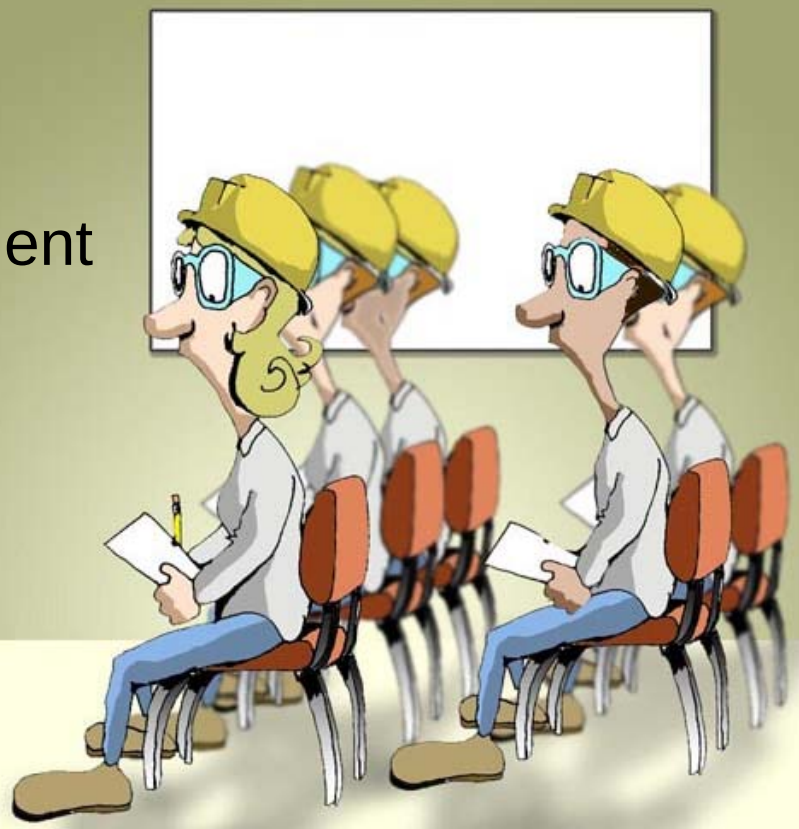
Be Safe Out There

ELECTRICAL
WORKPLACE SAFETY



Training

- Affected
- Task-Qualified
- Qualified
- Management
- May be OTJ or Classroom or combination
- Employees involved in LO/TO procedures must be trained.



Be Safe Out There

ELECTRICAL
WORKPLACE SAFETY

Program Analysis

Electrical safety is a four-step analysis process:

1. Establish an electrically safe work condition.
2. Provide training.
3. Plan the work.
4. Wear personal protective equipment.

Be Safe Out There

ELECTRICAL
WORKPLACE SAFETY

Safety First Never Ends

- Training and retraining must be provided and routinely updated.
- Programs must be audited and continuously updated.

Be Safe Out There

ELECTRICAL
WORKPLACE SAFETY

Be Safe Out There

ELECTRICAL
WORKPLACE SAFETY

If unsure, look it up!

The Human Side of Electrical Safety

Richard DeBusk, CSP, Safety Department
Clyde Saunders, Electrician, IBEW Local 77

Presented at the DOE Electrical Safety Committee Meeting
Las Vegas, Nevada July 26-29, 2004

United States Canada IBEW

CH2MHILL
Hanford Group, Inc.

According to Ray Jones in “Electrical Safety in the Workplace”

“Most electrical safety initiatives have been associated with equipment construction and installation. At the same time, most incidents are initiated by people. (Jones p. 64)”

United States Canada IBEW

CH2MHILL Hanford Group, Inc.

Why More Consideration is Needed

- Changes are ongoing in the way electricians perform their work.
- Over time, teamwork has increased to ensure electrical work is performed safely.
  - Engineering and safety involvement is increasing
- Accident rates are still too high, therefore more must be done.

United States Canada IBEW

CH2MHILL Hanford Group, Inc.

Electrical Work Practices Have Changed Over the Years

- Personal Protective Equipment (PPE)
- Test Equipment
- Training

United States Canada IBEW

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Personal Protective Equipment

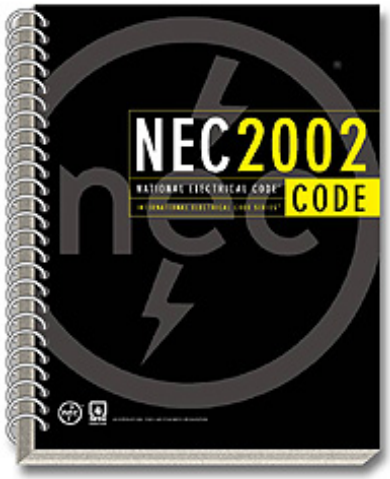
- In the past, electrical workers protected themselves.
- Today, there is a joint effort to ensure the worker is protected.
- Personnel protection is transitioning:
  - PPE (little available in the past)
  - Gloves and barriers (recently added)
  - Flame resistant clothing (available today)
- Coordination with safety and engineering ensures the right PPE is used.

Test Equipment

- In the past, the electrician had a narrow range of choices in test equipment
- Today, there are many choices and the equipment is changing rapidly.
  - Electricians must know which test equipment to use and how to use it
  - This requires keeping current with new equipment and ongoing training

Electrical Training

- The foundation for training the union electrical worker is the apprenticeship program.
- In the past, there was limited training beyond the apprenticeship.
- Today, state licensing and OSHA/ NFPA 70E require continuing training.
- Does your company actively promote professional training for electricians, engineers, and safety professionals?



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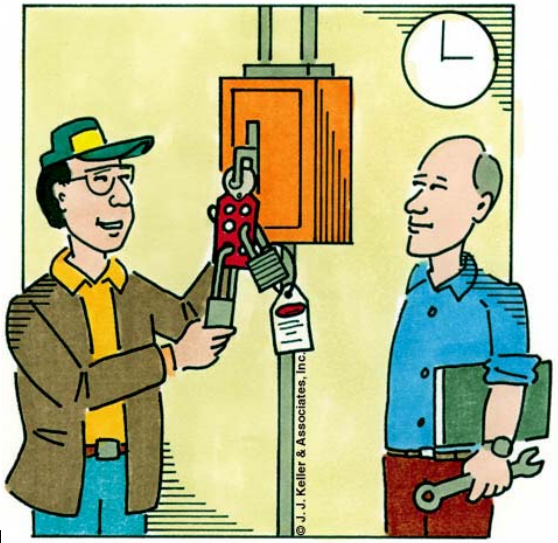
Teamwork is The Key to The Future of Electrical Safety



- Electrical engineers are learning how to perform arc-flash hazard calculations.
- Safety professionals are learning how to apply arc-flash hazard calculations into PPE and safe work recommendations in Job Hazards Analyses.
- Electricians are learning how to involve others in determining safe electrical work practices.

United States Canada IBEW

CH2MHILL Hanford Group, Inc.

Tools for Improving Teamwork

- Electrical Safety Committees
- Enhanced Work Planning
- Improved training
- No fault problem/issue reporting system
- Union/Management agreement to work together

We all agree to be advocates for electrical safety.

IEEE

ASSE

IBEW United States Canada

CH2MHILL Hanford Group, Inc.

Report on
Code-Making Panel 1

May 20 & 21, 2003

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

Proposal 1-25: Add Fine Print Note to 90.2(B)(4) and (5)

FPN: Utilities are organizations, typically designated or recognized by governmental law or regulation by public service/ utility commissions, that install, operate, and maintain electric supply (such as generation, transmission, or distribution systems) or communication systems (such as telephone, CATV, Internet, satellite, or data services). As such, the utility is subject to compliance with codes and standards covering these activities relevant to their industry as adopted under governmental law or regulation. Refer to the appropriate governmental bodies such as, state regulatory commissions, Federal Energy Regulatory Commission, and Federal Communication.

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2005 NEC® Proposals Report of CMP-1

Proposal 1-46: Add Definition of "Abandoned Cables"

Abandoned Cables. Cable that is neither terminated at both ends nor identified for future use with a tag.

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2005 NEC® Proposals Report of CMP-1

Proposal 1-84: Revise Definition of "Dwelling Unit"

Dwelling Unit. One or more rooms for the use of one or more persons as a housekeeping unit with space for eating, living, cooking, and sleeping, and permanent provisions for sanitation.

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

Proposal 1-97: Add Definition of "Grounding Electrode"

Grounding Electrode. A device that establishes an electrical connection to the earth.

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

Proposal 1-98: Revise Definition of "Grounding Electrode Conductor"

Grounding Electrode Conductor. The conductor used to connect the grounding electrode(s) to the equipment bonding conductor, to the grounded conductor, or to both, at the service, at each building or structure where supplied by a feeder(s) or branch circuit(s), or at the source of a separately derived system.

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

Proposal 1-114: Add Definition of "Kitchen"

Kitchen. An area used, or designated to be used, for the preparation of food.

Need given for definition was to identify areas of non-dwelling kitchens requiring GFCI protected 125-volt, single-phase, 15- and 20-ampere receptacles as per Section 210.8(B)(3).

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

Proposal 1-122: Add Definition of "Neutral Conductor"

Neutral Conductor. A conductor, other than a grounding conductor, that is connected to the common point of a wye connection in a polyphase system or the point of a symmetrical system which is normally at zero voltage.

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2005 NEC® Proposals Report of CMP-1

Proposal 128: Add FPN to Definition of "Qualified Person"

FPN: Examples of this safety training include, but are not limited to, training in the use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools and test equipment when working on or near exposed conductors and or circuit parts that are or can become energized.

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

Proposal 1-138: Add Definition of
"Supplementary Overcurrent Protective Device"

Supplementary Overcurrent Protective Device. A device intended to provide limited overcurrent protection for specific applications and utilization equipment such as luminaries (lighting fixtures) and appliances. This limited protection is in addition to the protection provided in the required branch circuit by the branch circuit overcurrent protective device.

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

Proposal 1-157: Relocate Table 430.91 to new Section 110.20

- Table provides enclosure types for various environmental conditions such as dry, wet, rain, sleet, dust, and other environments
- Table is similar to NEMA 250, Standard on 1000 Volt and Less Enclosures but is not as complete as NEMA 250
- Table relocated to Article 110 would now apply generally to NEC and not just to motor controller enclosures as currently in Table 430.91

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

Proposal 1-208: Conditions Under Table 110.26(A)(1) Revised

- Condition 1 – Exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space, or exposed live parts on both sides of the working space that are effectively guarded by insulating materials.

- Condition 2 – Exposed live parts on one side of the working space and grounded parts on the other side of the working space. Concrete, brick, or tile walls shall be considered as grounded.

- Condition 3 – Exposed live parts on both sides of the working space.

NFPA World Safety Congress & Exposition®
2005 NEC® Proposals Report of CMP-1

- Proposal 1-231: Accepts premise for over 600-volt equipment that only energized equipment requires specific working space

- **110.31(A) Working Space.** Except as elsewhere required or permitted in this Code, equipment likely to require examination, adjustment, servicing, or maintenance while energized shall have clear working space in the direction of access to live parts ……

- This section now duplicates the language and conditions in existing Section 110.26(A) for equipment 600 volt and less.

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2005 NEC® Proposals Report of CMP-1

Proposal 1-240: Relocates existing Part IV of Article 314 to new Part V of Article 110.

Manholes and Other Electric Enclosures Intended for Personnel Entry, All Voltages

Report on Panel Actions

CMP-2

Raymond W. Weber

Chair

May 20 & 21, 2003

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- 2-5 – (210 & 220): Accept
- The panel agreed with the TCC recommendation that the term " guest room" be replace with the phrase " guest rooms or guest suites". The term suites was added for clarity, the occupancies are identical whether the accommodation consists of one or more rooms.

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- 2-30 – (210.5 (C) (New); A/Principle
- Delete existing 210.4 (D) add new (C)
- For ungrounded conductors, in premises with more than one nominal voltage system, each ungrounded conductor of a branch circuit, where accessible, shall be identified by system. Means of ID shall be permitted to be by color coding, marking tape, tagging or other approved means and shall be permanently posted.

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- 2-32 – (210.6 (D) (2): A/Principle
- Revised, (2) Cord-and-plug connected or permanently connected utilization equipment other then luminaries (fixtures).
- The current text is interpreted to permit a 480-volt, delta-connected system to supply the ballasts of HID fixtures. This is in conflict with 210.6 (D) (1), requiring (22') on poles or (18') on other structures.

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- 2-70 – (210.8 (B)): A/Principle in Part
- Panel has added additional GFCI requirements for other than dwelling units.
- Add (4) Outdoors in public spaces for the purposes of this section a public space is defined as any space that is for use by or is accessible to the public. Panel statement noted it does not apply where the public does not have access.

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- 2-134a - (210.12(B)): Accept
- (B) has been revised stating " a listed AFCI, combination type installed to provide protection of the branch circuit". With an Exception, for location being permitted at other than the origination of the branch circuit under (1) AFCI installed within 1.8 m (6 ft) of the BC overcurrent device and (2) circuit conductors between the overcurrent device and AFCI are in metal raceway or a cable with a metallic sheath.

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- 2-167 (210.12(B) Excpt. #2 (New) A/Principle, to read:
- " AFCI protection shall not be required for an individual branch circuit supplying a dedicated outlet for life support equipment in dwelling unit bedrooms. Such receptacles shall be marked " Life Support Equipment Only". To note the only intended use.

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- 2-190 – (210.23(A)(1): A/Principle
- Add, “ not fastened in place” to the title and text since some cord and plug connected equipment may be fastened in place: e.g. food waste disposers, dishwashers, trash compactors, etc. Where complying with other Code rules, a multioutlet circuit may supply more than one of these loads.

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- 2-211a – (210.52(C) (1) Excpt.): Accept
- Exception to (1): Receptacle outlets shall not be required on a wall directly behind a range top or sink. The area directly behind a range top or sink is determined as shown in Figure 210.52. Receptacle outlets in this location shall not be considered as the required countertop outlets.

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- 2-211a – (210.52 (C) (2): Accept
- Island Counter Spaces. New second sentence. Where a range top or sink is installed in an island counter and the width of the counter behind the R/S is less than 12 inches, the R/S is considered to divide the island into two separate countertop spaces as defined in 210.52 (C) (4). New Figure.

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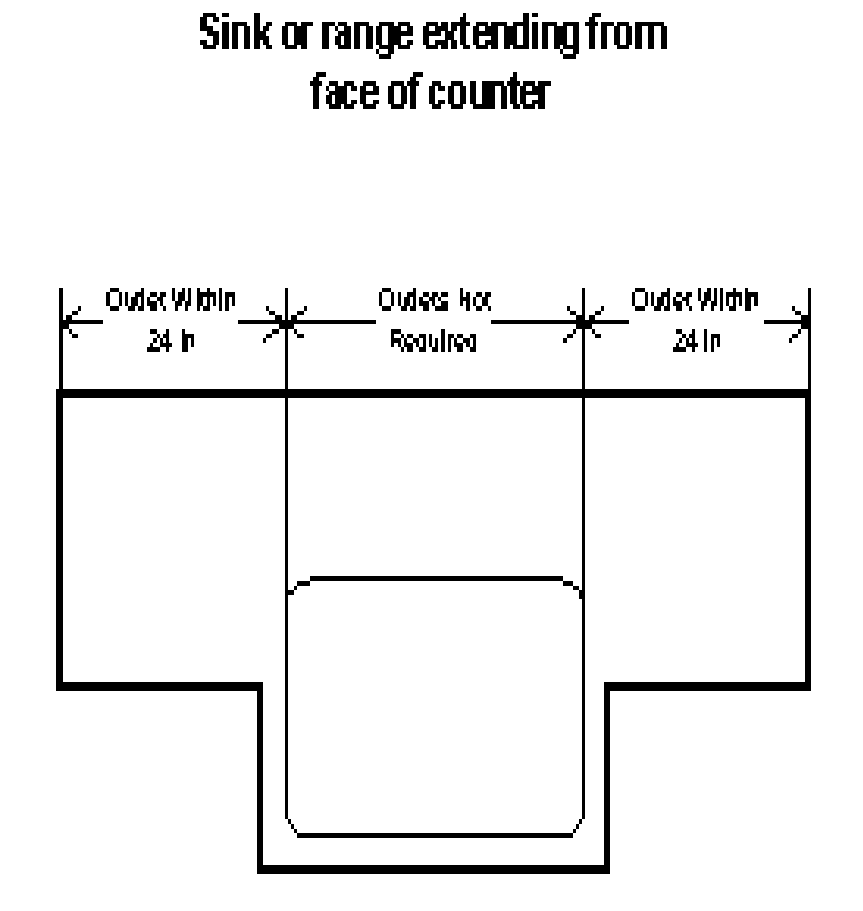

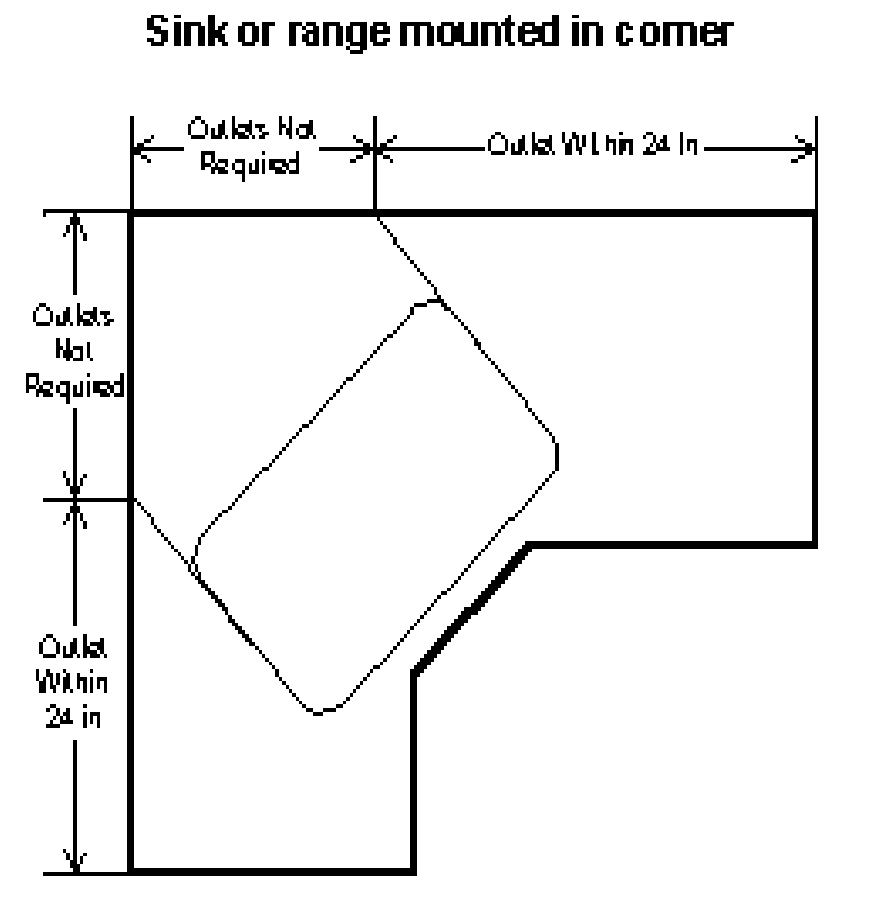

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- 2-229–(210.52(D) & Except.): A/Principle
- In dwelling units, at least one receptacle outlet shall be installed in bathrooms within 900 mm (3ft) of the outside edge of basin.
- Exception: The receptacle shall not be required to be mounted in the wall or partition where it is installed on the face of the basin cabinet not more than 300 mm (12in.) below the countertop.

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- 2-242–(210.60(A)): Accept, with comment.
- Guest rooms or guest suites provided with permanent provisions for cooking shall have receptacle outlets installed in accordance with all of the applicable rules in 210.52.
- Comment, Panel affirms its position that permanent provisions for cooking do not include equipment such as microwave oven.

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- 2-276 - (215.2(B)): A/Principle
- Feeders Over 600 Volts. Add new sentence
- Where installed, feeder circuit grounded conductors shall not be smaller than the required feeder equipment grounding conductor specified in 250.122.

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- 2-280 – (215.8): A/Principle
- Delete 2002 NEC 215.8, Means of Identifying Conductor with the Higher Voltage to Ground. Panel agrees since it is redundant and the requirement for high-leg marking is already covered in 110.15.

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- 2-289 – (215.12 (New)) A/Principle
- Similar to 2-30 – (210.5 (C) New). Feeders,
- Requiring identification of the grounded conductor in accordance with 200.6, equipment grounding conductor ID. Per 250.119 and ungrounded conductors for feeders where more than one nominal voltage system is present, where accessible shall be ID, and posted at panelboards.

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- 2-292 – (220): A/Principle
- Article Branch-Circuits, Feeders, and Service Calculations, was restructured by a Task Group of the TCC and submitted for consideration. The Panel accepted the proposal and has subsequently modified the proposals through the panel action on (220).

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- 2-298 – (220.3 (New)): Accept
- As noted in Proposal 2-292 previous change
- 220.3 Application of Other Articles. In other articles applying to calculation of loads in specialized applications, there are requirements provided in Table 220.3 that are in addition to, or modifications of, those within this article. Table provides a good cross reference to article and section number to enhance usability.

Report on Panel Actions
CMP-3

Richard Owen, Chair

May 20 & 21, 2003

Proposal 3-10, Section 300.3(B).

- The panel rejected this proposal which would require all conductors of a circuit, including the neutral, to be present in every outlet and switch box. This would require a 3-wire NMC cable for a switch loop, and four conductors in a cable for some applications.

Proposal 3-17, Section 300.4(2) (D).

- The Panel added a reference to furring strips to the section, clarifying that even though they may not be framing members, that the 1-1/4” clearance from any edge subject to nail or screw penetration must be maintained.

Proposal 3-24, Section 300.4(A) (1).

- The Panel accepted a new type of nail plate less than the standard 1/16 in. thick plate from previous codes. This plate must be listed as an equivalent to the 1/16in. plate plus be individually marked so the inspector can verify its listing even after installation.

Proposal 3-26, Section 300.4(A) (2).

- The panel accepted a proposal that clarifies that a nailer plate (or plates) must protect the wiring method for its entire length where subject to penetration. Otherwise, for example, where several cables are run together through a header, a single plate may not be big enough to protect all the cables. Also, it clarifies that you may need several plates end to end if a cable runs parallel to a framing member without the required 1-1/4 clearance.

Proposal 3-39a, Section 300.5(B)

- The Panel developed a proposal that would move the listing requirement for cables and conductors so that the requirement applies to all conductors and cables used underground, whether direct-buried or installed in a raceway. The requirement was formerly in a section addressing only direct-buried cables.

Proposal 3-47, Section 300.5(G).

- The Panel rejected a proposal to insert a minimum voltage requirement for sealing raceways as provided in 300.5(G). The panel did not agree that even though the voltage may be lower than the proposed 50 volts minimum that this would mean that corrosion could not occur.

Proposal 3-51, Section 300.6.

- The panel accepted an addition to the title which would clarify that this section addresses corrosion and other deterioration of metallic raceways. The Section was also re-written to better cover all possible types of corrosion or deterioration to all metallic systems. The corrosion-resistant compound required now must be listed.

Proposal 3- 67, Section 300.11(A) (1)

- The panel accepted an added phrase which clarifies that additional wires installed for wiring method support in a fire-rated ceiling may be attached to the ceiling grid.

Proposal 3-69, Section 300.11(C) new exception

The panel accepted the addition of an exception to the basic rule that cables cannot support each other unless listed for the purpose. The exception will now allow Class 2 cables intended solely for the purpose of controlling a piece of equipment to be supported by an AC or MC cable that feeds that same piece of equipment.

Proposal 3-72, 300.13(B)

- The panel rejected a proposal that would have required “pigtailling” all grounded (neutral) conductors on all circuits, not just on multiwire circuits. This would not have allowed the practice of using the terminals on a receptacle to continue the grounded conductor path on single circuits.

Proposal 3-81, Section 300.18(A), New Exception

- This exception clarifies that a sleeve used for mechanical protection of wiring methods is exempt from the requirement that raceways must be installed complete before installation of conductors.

Proposal 3-93, Section 300.22(B)

- The panel accepted a deletion of liquidtight metal conduit in this Section. This wiring method will no longer be allowed in manufactured ducts. It was eliminated from use in other spaces used for environmental air in the 2002 NEC

Proposal 3-101, Table 300.50

- The Panel accepted some language changes to clarify the uses of the table and accepted a new Note 5 which describes an alternative where solid rock is encountered.

Proposal 3-112, Section 527.4(B)

- The panel accepted the language from TIA 02-1 which clarifies that NMC Cable may be used for Temporary Installations in buildings of any height or construction type. The language of 334.10 in the 2002 NEC would have limited the use of NMC for temporary installations in some construction types unless the NMC was protected by a 15-minute fire-rated finish

Proposal 3-120, Section 527.5

- The panel accepted a proposal to require that all holiday lighting be listed by a recognized testing laboratory

Proposal 3- 126, Article 725

- The panel accepted a proposal developed by a task group of Panel 16, which had started this project prior to Articles 725, 727 and 760 being given to Panel 3. This proposal will set a uniform numbering system for all the “low voltage” articles so their format will be the same. These Articles are 725, 760, 770, 800, 820 & 830.

Proposal 3-157, Section 725.42

- The panel accepted a clarification that the marking required for class 2 & 3 circuits should be on the equipment at the source of the circuit, not necessarily at all other points on the circuit.

Proposal 3-162a, new Section 725.56(F)

- The panel developed a proposal that addresses the separation of Class 2 & 3 circuits from audio circuits using class 2 or 3 wiring methods. The audio circuits may be of a high enough amperage or voltage that a fault could affect Class 2 or 3 circuits, some of which are used for control of life safety equipment.

Proposal 3-173, Sections 725.61(A), 725.61(B) (1), 760.61(A) & 760.61(B) (1)

- The panel accepted the removal of the sentence "abandoned cables shall not be permitted to remain" to eliminate redundancy. It was noted by the panel that Sections 725.3(B) and 760.3(A) remain and that their location in the two articles still require removal of abandoned cables throughout the two articles.

Proposal 3- 223, Article 760

- The panel accepted a proposal to re-number Article 760 in the same format as 725, 770, 800, 820 & 830. See also Proposal 3-126.

Proposal 3-234, Section 760.6 new FPN

- A proposal was accepted to reference ANSI/NECA 305-2001, *Standard for Fire Alarm System Job Practices*. This non-mandatory FPN will give installers a reference for installation of fire alarm systems

Proposal 3- 256, Section 760.41

- A phrase was added to the sentence to require that the power supply for a fire alarm system not be connected to a circuit that is arc-fault protected

Proposal 3- 264a, Section 760.56(D)

- The panel added a paragraph that will prohibit PLFA circuits from being in the same cable or raceway as audio system circuits as described in Sect. 640.9(C). The possible higher voltage or amperage of the audio circuit could possibly damage the fire alarm circuit and affect its operation

Proposals 3-273, 3- 275 & 3-277

- The Panel Accepted Circuit Integrity cables to be used in the following Sections where 2-hour circuit integrity is needed:

➢ 760.61(A) FPLP-CI Cable

➢ 760.61(B) FPLR-CI Cable

➢ 760. 61(C) FPL-CI Cable

Proposal 3- 301, Chapter 9, Table 12(B)

- The column “Over 100 and Through 250” has been deleted since the system and equipment it refers to has not been manufactured in over 20 years. Existing systems of that type would still be legal since they were properly installed under a previous code.

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CODE MAKING PANEL 4

ARTICLES

225 Outside Branch Circuits and Feeders.

230 Services

May 20 & 21, 2003

CMP- 4 Panel Actions for 2005 NEC

- Proposal 4-25a (225.30(A)(6)) Accepted to revise text
- Add (6) Redundant systems for the purpose of enhanced reliability of the supply
- This clarifies an on going issue that redundant systems are often necessary where supplying critical loads (Computer, Security) that are not covered under 517 (Health Care Facilities) and 702 (Optional Standby Systems)

CMP- 4 Panel Actions for 2005 NEC

- Proposal 4-26a , This proposal combines the requirements of 225.31 and 225.32 for clarity and usability.
- Panel 4 over several code cycles has had many proposals requesting clarification on the distance from a building that a service or feeder can be located .
- The proposal was accepted at the panel meeting but received a five to five vote at the ballot stage.

CMP- 4 Panel Actions for 2005 NEC

- The sticking point is 225.31(A)(1) The location where the Branch Circuit or Feeder disconnect is located when <u>with-in sight from</u> the building or structure supplied.

CMP- 4 Panel Actions for 2005 NEC

- "…….six sets of disconnects per service grouped in any one location. For the purpose of this section, disconnecting means used solely for power monitoring equipment, transient voltage surge suppressors, or the control circuit of the ground-fault protection system or power-operable service disconnecting means, installed as part of the listed equipment, shall not be considered a service disconnecting means.

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Paul Dobrowsky
Eastman Kodak Co.
Member of NEC CMP 5

May 20 & 21, 2003

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ROP 5-1, 5-41, 5-45

Proposed Change:

Equipment Grounding Conductor (EGC)

to

Equipment Bonding Conductor (EBC)

Did **Not** receive the necessary 2/3 to be accepted.

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ROP 5-16 200.6(B) Means of ID Grounded Conductors Larger than 6 AWG

Accepted proposal to allow gray markings at terminations.

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ROP 5-37 Title & Scope of Article 250

Accepted a change to:

Article 250. Grounding <u>and Bonding</u>

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ROP 5-42 All of Article 250

A proposal to change the terms "ground" and "grounded", to "earth" and "earthed" was rejected.

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ROP 5-74 , 5-80, 5-84 250.28 Main Bonding Jumper <u>and System Bonding Jumper</u>

A proposal to add the concept of a system bonding jumper was accepted in principle. A proposal submitted to CMP 1 to add a definition of System Bonding Jumper was also accepted.

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ROP 5-78, 5-93, 5-94 250.30 Separately Derived Systems

A proposal to revise 250.30 was accepted in principle.

Common Grounding Electrode Conductor

Proposal 5-93 added the minimum common GEC size to be 3/0

Connection means is ~ *similar* to 250.64 for services

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ROP 5-109 250.32 Two or More Buildings or Structures Supplied from a Common Service

A proposal to change the title to:

Buildings or Structures Supplied by Feeder(s) or Branch Circuit(s) was accepted in principle

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ROP 5-128 250.52(A)(5) Rod and Pipe Electrodes

ROP 5-133 250.(A)(6) Plate Electrodes

ROP 5-144 250.56 Resistance of …

Proposals to require an minimum of two electrodes and remove the 25 ohm resistance requirement were rejected.

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ROP 5-154 250.64(B) Securing and Protection from Physical Damage (GEC)

A proposal to require the minimum burial depth for grounding electrode conductors to be 12 inches was accepted. A reduction in "cover" depth to 6 inches is permitted if beneath 2 inches of concrete or similar material.

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ROP 5-160, 5-161 250.64(D) Grounding Electrode Conductor Taps

Proposals to add the term "common" and a clarification of how to size the common GEC were accepted in principle. This would make this section consistent with the use in 250.30 for separately derived systems.

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ROP 5-162, 5-163, 5-165, 5-165, 5-184, 5-190 250.64(E) Enclosures for Grounding Electrode Conductors

Proposals to revise this section were accepted in principle to clarify where bonding was required for grounding electrode conductors installed in “ferrous” metal enclosures.

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ROP 5- 176 250.68(A) Exception [Accessibility of GEC connections]

A proposal to permit exothermic or irreversible connections to “fire-proofed structural metal” (removing the accessibility requirement) was accepted.

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ROP 5- 202 250.112 [Grounding Electrical Equipment-Specific -fixed]

A proposal to clarify where (point of grounding) the equipment is to be grounded (bonded) was accepted in principle.

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ROP 5-211 250.118 Ex. New

A proposal to require a “wire type” equipment grounding conductor” in metal conduit located on rooftops was accepted in principle.

This proposal was suggested to be referred to CMP 8 for action.

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ROP 5- 220 250.119 Identification of EGC's

A proposal to limited the use of green and green with yellow striped insulation for use only as EGC's was accepted.

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ROP 5-229 250.122(D) Size of EGC's

A proposal to remove the provisions for basing the EGC on the motor overload device for motor circuits protected by instantaneous trip circuit breakers or motor short circuit protectors was accepted. The remaining text would require the EGC to be based on 125% of the motor full load current.

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ROP 5-232 250.122(G) (New) Feeder Taps

A proposal to specify that the size of the EGC for feeder taps must not be smaller than that provided in Table 250.122 based on the OCD of the feeder was accepted in principle.

The "tap EGC" is not required to be larger than the tap supply conductors.

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ROP 5-267 285.3 TVSS Uses Not Permitted

A proposal to permit TVSS's on ungrounded systems where specifically listed for the use was accepted.

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Proposal #6-6a (310.4) / Accept

- **Initially labeled as CP 600, this proposal was generated by CMP 6 to avoid the use of additional wordage that did not add clarity to the Code.**

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Proposal #6-10a / (310.5 Exc.) / Accept

- Initially labeled as CP 601, this proposal was generated by CMP 6 to achieve a uniform presentation of the Code. All 10 exceptions were deleted.

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Proposal 6-88a / (400.7c) / Accept

- **Initially labeled as CP 602, this proposal was generated by CMP 6 to reduce the confusion regarding the application and use of "power strips". The 3 items address the confusion that existed.**

The National Electrical Code Technical Correlating Committee Identified concerns with using the terms

- "Uses Permitted" and
- "Uses not permitted"

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Panel 7 agreed with the concept of deleting the article of "Uses Permitted" and expanding the article for "Uses Not Permitted" in all sections that are panel 7's responsibility.

The articles with XXX.10 were thus deleted and the scope of articles with XXX.12 were expanded.

Proposal 7-15-(320.17) Accept

- Type AC cable shall be protected in accordance with 300.4(A), (C), and (D). Bushings not required for Type AC cable passing through holes in metal studs.

Proposal 7-72-(330.30)

Proposal 7-75-(330.30) AIP

Accept with scope revision

- Revise text to allow supporting and securing using staples, cable ties, straps, hangers, or similar fittings.

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Proposal 7-99-(334.10) Accept

- Delete Uses Permitted

Proposal 7-115-(334.12)

Accept with scope revision

- (1) For multifamily dwellings of other than types III, IV, and V construction
- (2) For non dwelling structures of other than types III, IV, and V construction and where the cables are not concealed within walls, floors, and ceilings that provide a thermal barrier of material that has at least a 15 minute finish rating as identified in listings of fire rated assemblies.

Proposal 7-150(A)-(334.80) Accept

- Add a new paragraph to 334.80 to read:

Where more than two NM cables containing two or more current carrying conductors are bundled together and pass through wood framing, which is to

be fire or draft-stopped using thermal insulation or sealing foam, the allowable ampacity of each conductor shall be adjusted in accordance with Table 310.15(B)(2)(a).

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Proposal 7-197-(340.10) Accept

- Delete Uses Permitted

Proposal 7-203-(340.12) Accept

- Accept with scope revision

(1) As a substitute form wiring method for NM cable unless the cable is of the multi-conductor type and the installation and conductor requirements comply with Parts II and III of Article 334.

(2) For cable tray installations unless the cable is of the multi-conductor type identified for the use.
(3) ……(13)…..in accordance with Part III of Article 396.

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CODE MAKING PANEL-10

ARTICLE 240 Overcurrent Protection

ARTICLE 780 Closed-Loop and Programmed Power Distribution

May 20 & 21, 2003

CMP-10 Panel Actions for 2005 NEC

- The panel added new text as follows:
- “.. shall be considered to be protected when applied within the appliance or portable lamp listing requirements, ..”

CMP-10 Panel Actions for 2005 NEC

- An additional list item was added to address "Field assembled extension cord sets" allowing 16 AWG or larger on 20-amp branch circuits

CMP-10 Panel Actions for 2005 NEC

- CMP-10 Accepted Proposal 10-39, replacing the term “approved” with the term “identified” in 240.20(B)(1), (2) & (3)
- “Approved” circuit breaker handle ties could include nails, screws etc.
- “Identified” circuit breaker handle ties are readily available from circuit breaker manufacturers and are designed for the purpose

CMP-10 Panel Actions for 2005 NEC

- Proposal 10-35, suggested a relocation of 240.20(B) from “Part II Location” to “Part I General”
- Accepted in Principle
- The Panel action separates the existing requirement into two separate sections as follows:

CMP-10 Panel Actions for 2005 NEC

- NEW SECTION
- 240.15(B) Circuit Breaker as Overcurrent Device.
- NEW SECTION
- 240.16 Circuit Breaker as a Disconnecting Means (1) Multiwire Branch Circuit. (2) Grounded Single-Phase and 3-wire dc Circuits. (3) 3-Phase and 2-Phase Systems.

CMP-10 Panel Actions for 2005 NEC

- Proposal 10-57, suggested text to improve the clarity of 240.21(C)(3)(1)
- Accepted in Principle
- The present text is unclear in application to a single or multiple sets of secondary conductors
- The panel action is intended to improve the clarity of all list items in 240.21(C)

CMP-10 Panel Actions for 2005 NEC

- To improve clarity 240.21(C) is revised as follows:
- "(C) Transformer Secondary Conductors. <u>Each set of conductors feeding separate loads</u> shall be permitted to be connected …"

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Proposal # 11-6 **Code Section: Art 430 New Part X**

•Proposal 11-6, recommending creation of a new Part X in Article 430 to address the issues of "Adjustable Speed Drive Systems" was accepted. This recommended change places requirements for these drive systems in a central location in Article 430.

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Proposals # <u>11-8 and and numerous others</u>

Code Sections: <u>Art 430.81(A) various others</u>

•Several proposals were accepted that recommended relocation of definitions from various sections throughout Articles 430 and 440 to 430.2 and 440.2 which is intended to make the code more user friendly.

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Proposal # 11-19 **Code Section: Art 430.8**

•Proposal 11-19 recommending that motor controllers be marked with the "short circuit current rating" was accepted in principal. While there was general agreement with this concept, the panel determined that there should be exceptions for certain motor controller applications.

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Proposals # <u>11-88a (11-15)</u> **<u>Code Sections:Tables 430.148, 430.149, 430.150 & 430.6(A)(1)</u>**

•Panel Proposal 11-88a was written by CMP-11 in response to Proposal 11-15 submitted by the TCC relative to Comment 11-6 held over from the 2002 cycle. Proposal 11-88a affecting Tables 430.148, 430.149, 430.150 and Section 430.6 (A) (1) was developed to require the use of the nameplate current rating for low speed, high torque motors instead of the table values. This requirement was relocated from the Table headers and placed in Section 430.6 (A) (1).

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Proposal # 11-93 **Code Sections: 440.2 & 440.60**

•Proposal 11-93 which was submitted to add definitions for "room air conditioners", "packaged terminal air conditioners", and "packaged terminal heat pumps" in Article 440 was rejected because these terms are not used in the Code. This same proposal also recommend that PTAC and PTHP units not be required to have LCDI or AFCI protection for power cords. Requirements for use of these devices in the power cords were introduced into the NEC in the 2002 cycle.

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Proposal # 11-110 **Code Section: 440.65**

•Proposal 11-110 recommending that Section 440.65 be deleted from the Code was rejected. This section was added to the Code during the 2002 cycle. The panel felt at that time that the requirements of Section 440.65 provided a necessary level of safety for power cords of room air conditioners. The panel has maintained in the 2005 cycle that this protection is still needed.

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Proposal 12-61 Section 645.5(D)(5)

This proposal will allow the power supply cord of listed equipment to be installed under a raised floor in an Information Technology Room without the cord meeting the requirements of DP cable.

The Panel voted to accept in Principle. One member voted negative and his strongly worded and lengthy comments can be seen in the ROP.

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Proposals 12-74 thru 12-88 Article 670

Most of these proposals were the work of a Task Group that consisted of members of CMP 12 and NFPA 79.

The purpose of the Task Group was to increase usability of Article 670 and to better align this Article with NFPA 79, Electrical Standard for Industrial Machinery 2002 Edition.

CMP 12 either accepted or accepted in principle the proposals of the Task Group.

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CMP-13

Chair-Thomas H. Wood

Articles 445, 455, 480, 690, 692, 695, 700, 701, 702, 705

Acted on 154 Proposals

Developed 3 Panel Proposals

May 20 & 21, 2003

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Proposal #:13-5 NEC Section: 445.11

Each generator shall be provided with a nameplate giving the manufacturer's name, the rated frequency, power factor, number of phases if of alternating current, **the subtransient and transient impedances**, the rating in kilowatts or kilovolt amperes, the normal volts and amperes corresponding to the rating, rated revolutions per minute, insulation system class and rated ambient temperature or rated temperature rise, and time rating.

Revisions to 70E will require calculation of arc energy for electrical equipment. The generator impedance value will be needed for this calculation.

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Proposal #:13-7 NEC Section: 445.18

Generators shall be equipped with **disconnect(s)** by means of which the generator and all protective devices and control apparatus are able to be disconnected entirely from the circuits supplied by the generator except where: ... "

If this were done then two or three circuit breakers, at the generator, feeding different transfer switches, could be installed. This would add needed flexibility in certain situations. It would also allow portions of the emergency system to be more easily maintained without the need to take the entire system out of service and given the difficulty in getting needed shutdowns in facilities like hospitals and data centers, the overall reliability of those systems would be enhanced due to the (relative) ease in arranging needed shutdowns

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Proposal #:13-86 NEC Section: 695.4(B)(2)

(2) Disconnecting Means. The disconnecting means shall comply with all of the following:

(1) Be identified as suitable for use as service equipment

(2) Be lockable in the closed position

(3) Not be located within equipment that feeds loads other than the fire pump

(4) Be located sufficiently remote from other building or other fire pump source disconnecting means such that inadvertent contemporaneous operation would be unlikely.

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Proposals #:13-85,13-88,13-89 NEC Sections: 695.4(B)(1), 695.5(B) & 695.5(C)(2)

(1) Overcurrent Device Selection. The overcurrent protective device(s) shall be selected or set to carry indefinitely the sum of the locked-rotor current of the fire pump motor(s) and the pressure maintenance pump motor(s) and the full-load current of the associated fire pump accessory equipment when connected to this power supply. **The requirement to carry the locked-rotor currents indefinitely shall not apply to conductors and any other devices in the fire pump motor circuit(s).**

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Proposal #:13-100 NEC Section: 695.6(C)(2)

(2) Fire Pump Motors Only. ~~Conductors supplying only a fire pump motor(s) shall have a rating not less than 125 percent of the fire pump motor(s) full load current(s)~~. **Conductors supplying only a fire pump motor shall have a minimum rating in accordance with 430.22. Larger conductors may be necessary to satisfy the requirement in 695.7.**

Current 695.6(C)(2) offers no guidance for selection of conductors for reduced-voltage start motors. Reference to 430.22 provides requirements for sizing conductors for both across-the-line and reduced voltage start motors. Reference also reemphasizes that sizing is based on motor full-load current and not overcurrent protective device settings.

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Proposal #:13-105 NEC Section: 695.6(H)

Ground Fault Protection of Equipment. Ground fault protection of equipment shall not be permitted for fire pumps.

The text in 215.10 Exception No. 2, 230.95 Exception No. 2, and 240.13 which states that the requirements of these sections shall not apply to fire pumps is not sufficient to mandate that ground fault protection of equipment for fire pumps shall not be permitted.

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Proposal #:13-110 NEC Section: 700.6(A)

Transfer equipment, including automatic transfer switches, shall be automatic, **listed** for emergency use, and approved by the authority having jurisdiction.

Note: Same change accepted for 701.7(A)(13-138)

By substituting the term "listed" for the presently used "identified" which are both defined terms, this proposal intends to require that this equipment be subject to periodic follow-up inspection of production equipment to ensure suitability for emergency purposes.

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Proposal #:13-118 NEC Section: 700.9(D)(1)

Emergency-circuit wiring shall meet one of the following conditions.

Critical fire protection systems require operational integrity throughout the duration of a fire. Because of this, numerous codes and standards, including various model building codes and other NFPA documents require that all portions of the power wiring fed from the Article 700 complying system have a suitable level of circuit integrity and survivability. It is of utmost importance that NFPA 70, National Electrical Code, offer a code-complying method of meeting these requirements. The current wording limits the circuit integrity and survivability feature to feeder circuits. It is crucial that the NEC make provision for circuit integrity and survivability to apply to all portions of the power wiring in order to provide supportive correlation with the other codes and standards that require this.

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Proposal #:13-128 NEC Section: 700.12(E)

Fuel Cell System. Fuel cell systems used as a source of power for emergency systems shall be of suitable rating and capacity to supply and maintain the total load for not less than 2 hours of full-demand operation. Installation of a fuel cell system shall meet the requirements of Article 692. Where a single fuel cell system serves as the normal supply for the building or group of buildings concerned, it may not serve as the sole source of power for the emergency standby system.

Note: Similar text also accepted for 701.11(F)(13-143)

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Proposal #:13-128 (con't) NEC Section: 700.12(E)

It seems clear that the present pace of research, development, and testing of fuel cell technology will have matured to the point where such systems may be in general use by the 2005 through 2007 code cycle. Reliability is matched to already existing sources of power for emergency standby systems. For reference, I have provided an article from the January issue of Electrical Contractor Magazine, Fuel Cells Now: An Update. It, along with the material referenced in the article supports the need of this code provision.

The above proposal would be a logical insertion, moving the existing 700.12(E) to become 700.12(F). Code language mirrors that of the rest of the article. The 2 hour requirement mirrors that of 700.12(B)(2). It seems logical to have the same time requirement of this fuel source.

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Proposal #:13-134 NEC Section: 700.27

700.27 Series Rated Combinations.

Series Rated Combinations shall not be used in emergency systems.

Note: Same text added in 701.18 (13-144) for legally required standby systems

Series Rated Combinations use two devices to clear a fault, both the upstream fuse or circuit breaker and the downstream circuit breaker. If a fault occurs on an emergency system, the operation of the upstream device could take down the entire emergency system. This would create a situation that is unsafe for human life and violate the scope of Article 700. Series Rated Combinations must not be allowed in emergency systems for this reason.

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Proposal #:13-135 NEC Section: 700.28

Coordination. Emergency system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.

Note: Same text added in 701.19 (13-145) for legally required standby systems.

Panel Statement: The panel agrees that selective coordination of emergency system overcurrent devices with the supply side overcurrent devices will provide for a more reliable emergency system. By excepting in principle this proposal the FPN in Section 700.25 is no longer needed to alert users about selective coordination. The part the panel accepts is selective coordination of emergency systems. The panel's wording accomplishes the intent of the submitter without adding design aspects of selective coordination into this section.

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Proposal #:13-148 NEC Section: 702.6

Exception: Temporary connection of a portable generator without transfer equipment shall be permitted in industrial installations, with written safety procedures, where conditions of maintenance and supervision insure that only qualified persons service the installation and where the normal supply is physically isolated by a lockable disconnect means or by disconnection of the normal supply conductors.

When installed by qualified personnel in an industrial environment, a generator connected temporarily to an existing distribution system which has been properly isolated from the normal supply and locked out provides a safe source of portable power.

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Proposal #:13-149 NEC Section: 702.7

Exception: Signals shall not be required for portable standby power sources.

This section made perfect sense when only permanently installed sources were included in the scope of Article 702. Now that portable sources are included, there is no point in signaling derangement or carrying load in a system that must be manually connected and may not even be on site until a power outage occurs. Essentially, for a portable source, it is always "deranged" until connected and the fact that it is carrying load is obvious to the user who had to hook it up. In some cases, the same generator may not even be used for each event, or there may only be a provision for hooking up a generator in the event the user chooses to acquire one. Furthermore, many if not most small portable generators sold and used for this purpose have no provision for furnishing an external signal when carrying load.

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Proposal #:13-152 NEC Section: 702.11

IV. Sources of Power

702.11 Outdoor Generator Sets. Where an outdoor housed generator set is equipped with a readily accessible disconnecting means located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors enter or pass through the building or structure.

The new Part would permit the disconnecting means for the generator to act as the required disconnecting means for the circuit entering or passing through a separate building or structure as required by 225.31 with the same text as provided for generator sets for emergency and legally required standby generators.

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Significant Proposals and Actions

For CMP-14

Panel 14 acted on 146 public proposals and 14 panel proposals. This presentation will provide a brief discussion of the most significant proposals that were accepted in the ROP phase of the 2005 NEC cycle.

May 20 & 21, 2003

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Proposal 14-8

NEC 500.2

The 2002 NEC definition in 500.2, for "Purged and Pressurized", only includes text related to purging an enclosure. The additional text, also extracted from NFPA 496, clarifies that the protection technique includes both purging and pressurizing the enclosure.

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Proposal 14-13

NEC 500.7(K)

The revised text clarifies that a gas detection system must include items included in recommended practices that involve maintenance and operation requirements, in addition to installation requirements, for the protection technique to operate safely. All of these items must be documented before the protection technique is accepted.

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Proposal 14-34

NEC 501.15(B)(2)

Where a boundary seal is not also completing an explosionproof enclosure, there is no technical reason for the seal to be explosionproof. In a Division 2 location, the conduit would only have gases or vapors in an abnormal condition. The likelihood of having gases or vapors in a Division 2 location conduit and having an electrical fault to provide an ignition source simultaneously is very remote. The NEC will now consider this an acceptable risk. The only purpose for the seal is to minimize the amount of gas or vapor within the Division 2 location that can pass to an unclassified area.

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2005 NEC® Proposals Report of CMP-14

Proposal 14-40

NEC 501.15(F)(3)

NEC 501.15(F)(3) will now include two options for process sealing. The option located in the (a) part is the new text and includes instruments that are listed as and marked "Dual Seal". The option of providing an additional external seal is now located in the (b) part. This will continue to give manufacturers of single seal devices an opportunity to provide these devices and the installers provide the external seal. In the past, it was implied that a device that was dual sealed was not required to have an additional external seal, but there was no listing and marking requirement to determine the reliability of a manufacturers claim to a dual sealed device.

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Proposal 14-47

NEC 501.10(B)(7)

A non-shielded MV cable has a surface discharge from the cable surface to any ground plane (such as metal cable tray). This discharge is an ignition source that can cause an explosion in the event of gas or vapors being present. The new wording will require the single conductor MV cable to have a shield or metallic armor to provide a ground plane. This ground plane will eliminate any external electrical discharge thus eliminating the ignition source and precluding any possibility of creating an explosion.

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Proposal 14-63

NEC 503.10(A)(3)

The wiring methods in Class III, Division 1 locations are very similar to those found in Class II, Division 2 locations. Nonincendive field wiring was added to Class I, Division 2 and Class II, Division 2 in the 2002 code cycle. This change will permit the same applications to be applied in Class III, Division 1 locations.

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Proposal 14-67

NEC 504.10(B)

In the 2002 NEC, CMP-14 included an exception in 504.4 that says: Simple apparatus, as described on the control drawing, shall not be required to be "listed." This change will provide guidance for installers and inspectors to evaluate this equipment in the field.

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Proposal 14.79

NEC 505.18(A)

The new test clarifies that all conductors that enter an increased safety enclosure must be terminated in an increased safety terminal. It was not clear before that spares were required to be terminated in an increased safety terminal or if they could be taped or terminated with a wire nut or some other means. This protection technique is based on the quality of conductor terminations within an enclosure. These listed terminals greatly minimize the chance of terminations within an enclosure becoming an ignition source.

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Proposal 14-85

NEC 505.8(I)

The revised text clarifies that a gas detection system must include items that are part of recommended practices that involve maintenance and operation requirements, in addition to installation requirements, for the protection technique to operate safely. All of these items must be documented before the protection technique is accepted.

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Proposal 14-100

NEC 505.15(C)(1)(B)

A non-shielded MV cable has a surface discharge from the cable surface to any ground plane (such as metal cable tray). This discharge is an ignition source that can cause an explosion in the event of gas or vapors being present. The new wording will require the single conductor MV cable to have a shield or metallic armor to provide a ground plane. This ground plane will eliminate any external electrical discharge thus eliminating the ignition source and precluding any possibility of creating an explosion.

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Proposal 14-108(a)

Article 506

This proposal will add a new Article 506 to provide an alternate method of addressing concerns for electrical installations in atmospheres where fire and explosion hazards may exist due to flammable dusts, fibers and flyings. This would be an alternative to the requirements located in Articles 500, 502 and 503 for electrical installations in these environments.

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Proposal 14-111

NEC 511.3

NEC 511.3 has been reorganized so that all text related to unclassified locations within commercial garages is now located in 511.3(A) and all text related to classified locations is now located in 511.3(B). Some of the text in past editions was included as exceptions, some was located in Article 514 and some was already in 511.3 (A) or (B).

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Proposal 14-115

NEC 511.4

NEC 511.4(A) (1) and the exception will be deleted. This eliminates the text that indicated the space within a slab or masonry wall or below the slab was a Class I Location in some conditions. The definition of a Class I location in Article 500 requires an ignitible concentration of fuel and air be present for a classified location to exist. It was determined that unless there was a void in these areas where air could collect, there would not be enough oxygen to create an ignitible concentration. Now the applicable rules for wiring and sealing, located in Article 501 will apply to raceways entering classified locations from the unclassified areas within or below a slab.

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Proposal 14-122

NEC 514.8

This revision will eliminate the text that indicates the space within the earth, below a classified area, is a Class I Location. The definition of a Class I location in Article 500 states an ignitible concentration of fuel and air must be present for a classified location to exist. It was determined that unless there was a void in these areas where air could collect, there would not be enough oxygen to create an ignitible concentration. Now the requirements for raceways installed under the classified areas include a seal where the raceway emerges from below grade, but does not classify the space that does not include enough oxygen to reach an ignitible concentration.

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Proposal 14-132

NEC 513.12

This new section adds GFCI protection for 15 & 20 ampere, 125 volt, single phase, 50/60 Hz. receptacles that are installed in aircraft hangers. To avoid confusion, CMP-14 limited the requirement to 50/60 Hz devices. Many hangers include 400 Hz equipment which were determined not to be compatible with GFCI protection.

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Responsible for Articles 517, 518, 519, 520, 525 and 530

A Total of 114 Proposals Acted on

- 4 on Entire Document
- 56 for Article 517
- 19 for Article 518
- 1 for Article 519
- 16 for Article 520
- 13 for Article 525
- 4 for Article 530
- 1 for Annex G

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Proposal 15-42 (517.30 C(3)) introduced the use of listed Type MC cable and listed Type AC cable as acceptable wiring methods for emergency systems in hospitals.

The panel accepted this proposal in principle, limiting the use of Types AC and MC cables to existing installations where it is impractical to install non-flexible metal raceway.

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Article 518

The panel decided to re-title Article 518 to "Assembly Occupancies" and to make the scope statement consistent with NFPA 1, NFPA 101 and NFPA 5000.

518.1 Scope: Except as required in Articles 520, 525 and 530, the provisions of this article shall apply to electrical construction and installation criteria in all buildings or portions of buildings or structures designed or intended for the assembly or gathering together of 100 or more persons for such purposes as deliberation, worship, entertainment, eating, drinking, amusement, awaiting transportation or similar purposes."

NFPA World Safety Congress & Exposition® 2005 NEC® Proposals Report of CMP-16

Stanley D. Kahn – Chairman

Dr. Stanley Kaufman - Presenter

Restructuring

General Arrangement (Articles 800, 820 & 830)

I. General
II. Wires & Cables Outside & Entering Buildings
III. Protection
IV. Grounding Methods
V. Wires & Cables Within Buildings
VI. Listing Requirements

(Article 770 is similar.)

Editorial Changes

- Simplified cable marking and substitution tables
  - Removed "Use and References" columns
- Clarified cable removing requirement
  - Revised "The accessible portion of abandoned optical fiber cables shall not be permitted to remain." to "The accessible portion of abandoned optical fiber cables shall be removed."
- Corrected errors in 2002 Code dealing with the removal of abandoned cable
  - General removal requirement in sections xxx.3.

800.50 Exception 3 – 2002 NEC

Exception No. 3: Listing and marking shall not be required where the length of the cable within the building, measured from its point of entrance, does not exceed 15 m (50 ft) and the cable enters the building from the outside and is terminated in an enclosure or on a listed primary protector.

New Definitions Accepted

Term	Source
Air Duct	NFPA 90A-2002, 3.3.5
Ceiling Cavity Plenum	NFPA 90A-2002, 4.3.10.2
Raised Floor Plenum	NFPA 90A-2002, 4.3.10.6.1
Duct Distribution Plenum	NFPA 90A-2002, 4.3.10.3
Apparatus Casing Plenum	NFPA 90A-2002, 4.3.10.4
Air-Handling Unit Plenum	NFPA 90A-2002, 4.3.10.5

Conflict Eliminated!

2002 NEC (Articles 770, 800, 820, 830)
Ducts, Plenums and Other Space Used For Environmental Air

Air Duct	Plenum, Air Handling Unit Room	Plenum, Apparatus Casing	Plenum, Duct Distribution	Plenum Raised Floor	Plenum Ceiling Cavity	Other Space Used For Environmental Air

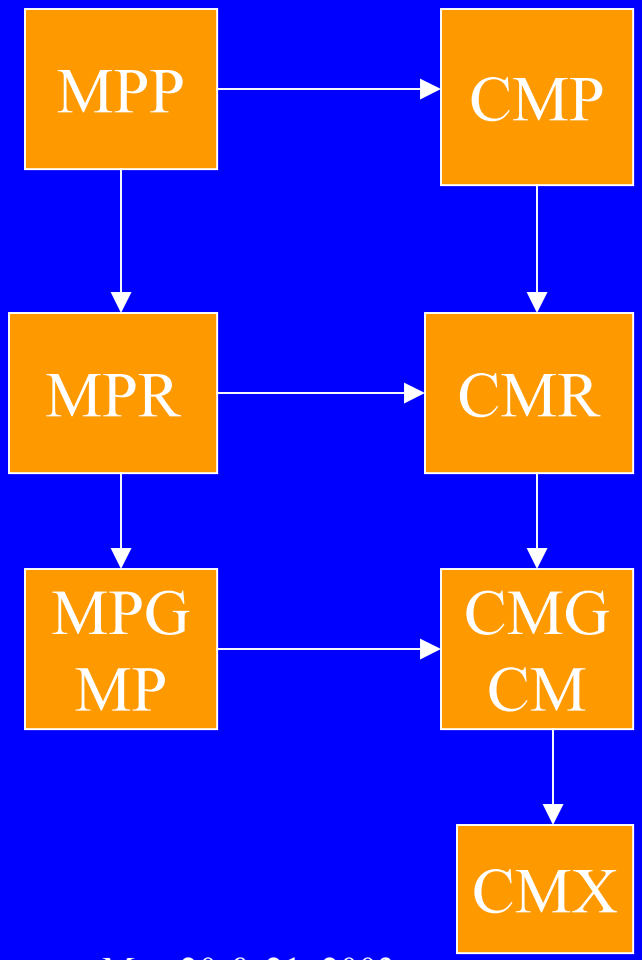
2002 NFPA 90A, Ceiling Cavity and Raised Floor Plenums

Conflict

Correlation

Elimination of “G” and “MP” Cables

Multipurpose and “G” cables do not have unique applications.



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CMP-17

Chair-Don Jhonson

Articles 422, 424, 426, 427, 680

Acted on 168 Proposals

Developed 13 Panel Proposals

May 20 & 21, 2003

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Proposal #: 17-24 NEC Section:422.31(B)

For permanently connected appliances rated over 300 volt-amperes or 1/8 hp, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the appliance or is capable of being locked in the open position. <u>The provision for locking or adding a lock to the disconnecting means shall be permanently installed on or at the switch or circuit breaker used as the disconnecting means.</u>

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Proposal #: 17-53 NEC Section:427.27

In industrial establishments, the isolation transformer connected to the pipeline or vessel being heated shall not have an output voltage greater than 132 volts ac to ground where all of the following apply:

(1) Conditions of maintenance and supervision ensure that only qualified persons service the installed systems.

(2) Ground fault protection is provided.

(3) The pipeline or vessel being heated is completely enclosed in a grounded metal enclosure.

(4) The transformer secondary connections to the pipeline or vessel being heated are completely enclosed in a grounded metal mesh or metal enclosure.

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Proposal #: 17-53 (con't) NEC Section:427.27

Industry is finding that impedance heating is a very efficient heat exchanger for heating fluids to a high temperature. The only temperature limitation is the withstand temperature of the piping material used as the heater. These heat exchangers are fully enclosed in metal vessels, with the only exposure the inlet end outlet connections, which are kept at ground potential.

If the code is modified in accordance with the proposal, installations like this will require fewer transformers, reducing capital costs and making electrical heating more competitive when evaluated against other kinds of heating. In addition standard transformer configurations, the 132 voltage to ground limitation will include a 120/208V three phase transformer set at its +10 percent tap, can be used, further reducing cost and construction time. These installations are at least as safe as motor installations in industrial plants, where voltages can range up to 13.8 kV.

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Proposal #: 17-154 New Article 682

Article 682 Natural and Artificially Made Bodies of Water

I. General

682.1 Scope. This article applies to the installation of electrical wiring for and equipment in and adjacent to natural or artificially made bodies of water not covered by other articles of this *Code.*

682.2 Definitions.

Natural Bodies of Water. Bodies of water such as lakes, streams, ponds, rivers or other naturally occurring bodies of water, and which may vary in depth throughout the year.

Artificially Made Bodies of Water. Bodies of water that have been constructed or modified to fit some decorative or commercial purpose such as, but not limited to, Aeration Ponds, Fish Farm Ponds, Storm Retention Basins, Sewage Treatment Ponds, Irrigation (Channels) Facilities.

Articles Responsible for:

406 – Receptacles, Cord Connectors, & Attachment Plugs

410 – Luminaries, Lampholders & Lamps

411 – Lighting Systems Operating at 30 Volts or less

600 – Electric Signs & Outline Lighting

605 – Office Furnishings (Consisting of Lighting Accessories & Wired Partitions)

18-33 [406.8(B)]

- Would require weatherproof covers on all receptacles in wet locations.
- Panel does not agree that all covers need to be weatherproof whether a cord is connected or not.
- Also see 18-35
- Reject

18-41 [406.8(C)]

- New wording, “Receptacles shall not be installed within or directly over the bathtub or shower stall.”
- Accept in Principle

18-61 [410.15(B)]

- Change would allow the use of metal or nonmetallic poles for the support of luminaires, such as parking lot fixtures.
- Accept

2004 DOE Electrical Safety Handbook

Chapter 11

Electrical Safety During Excavations

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What comes to mind when you think “procedures”?

DOE Operating Experience Summaries

Excavations Problems

- **Trenching**
- **Drilling**
- **Demolition**

Resource :

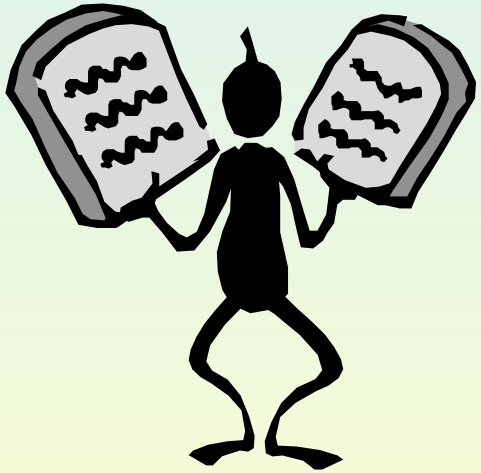
www.eh.doe.gov/paa

Yard Excavations

Concrete Drilling

Well Drilling

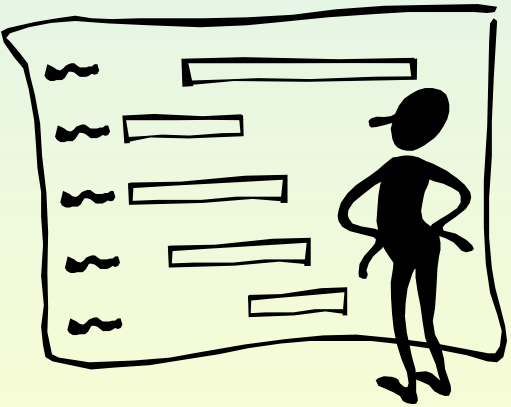
Topics addressed in Chapter 11



* Utilities Identification
* Utilities Verification and Marking
* Utilities Disposition
* Work Control During Excavation Activities
* As-Built Drawings

Utilities Identification

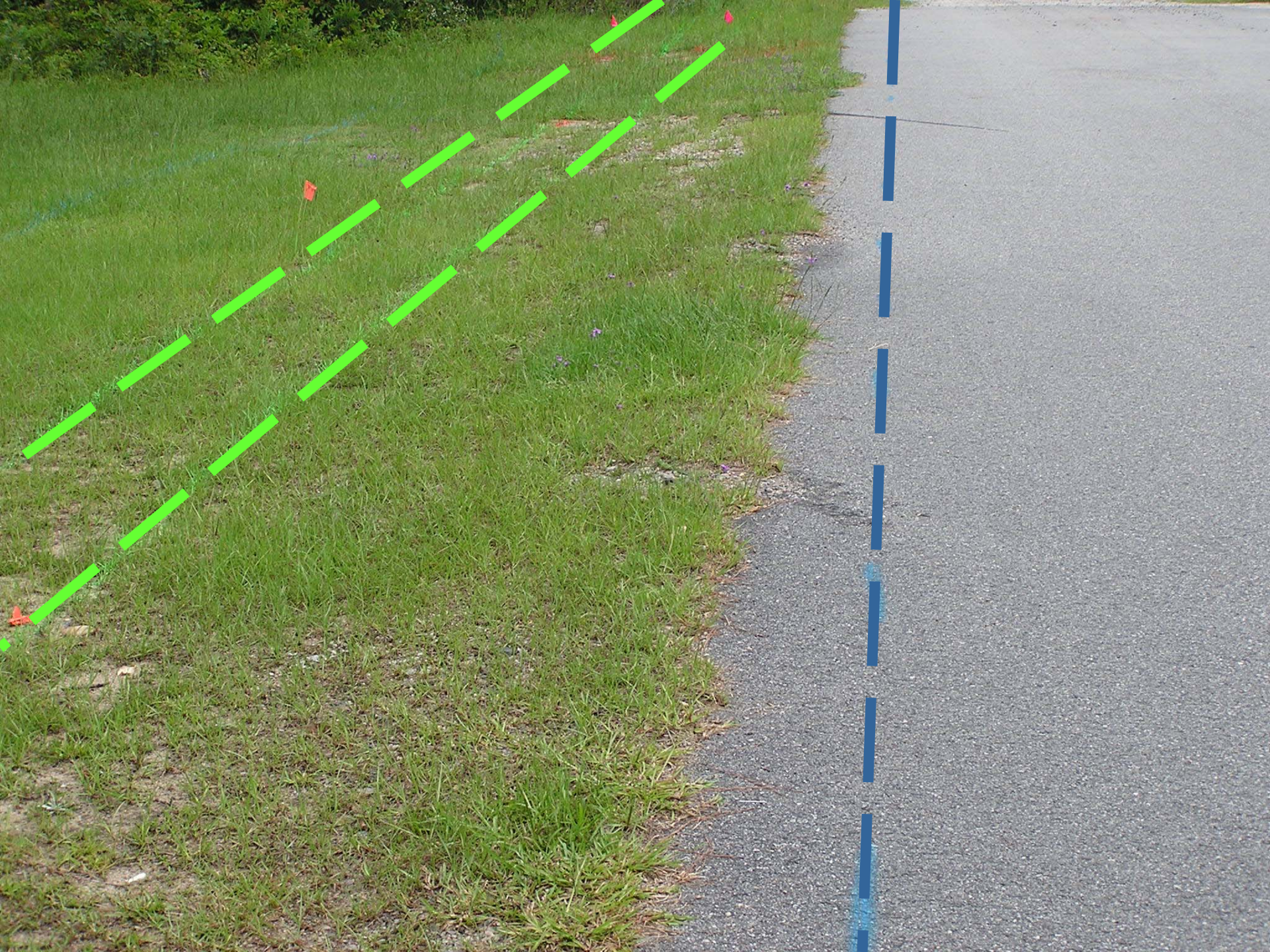
* Configuration Management
* Excavation Permit
* Locator Equipment



Utilities Verification and Marking

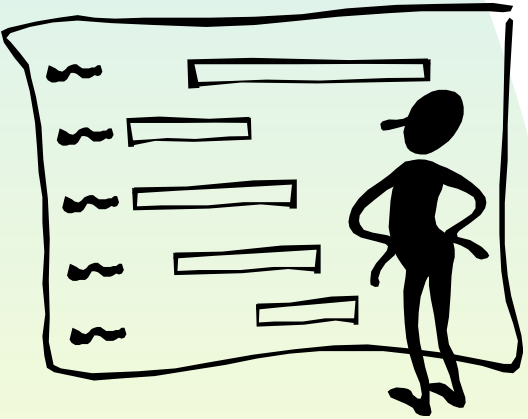
* Field Walkdowns
* Validate Known Commodities
* Locator Equipment Use
* Painting and/or Flagging
* Controlled Excavation Boundaries

Ground Penetrating Radar (GPR)



Mowing & Flag Replacement

Utilities Disposition



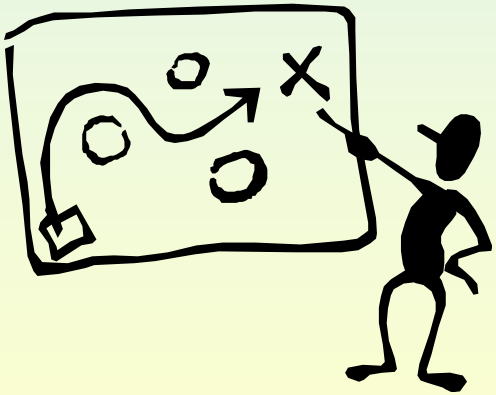
* Planned Outages
* Lockout / Tagout

Work Control During Excavations

* Procedures
* Safety Equipment

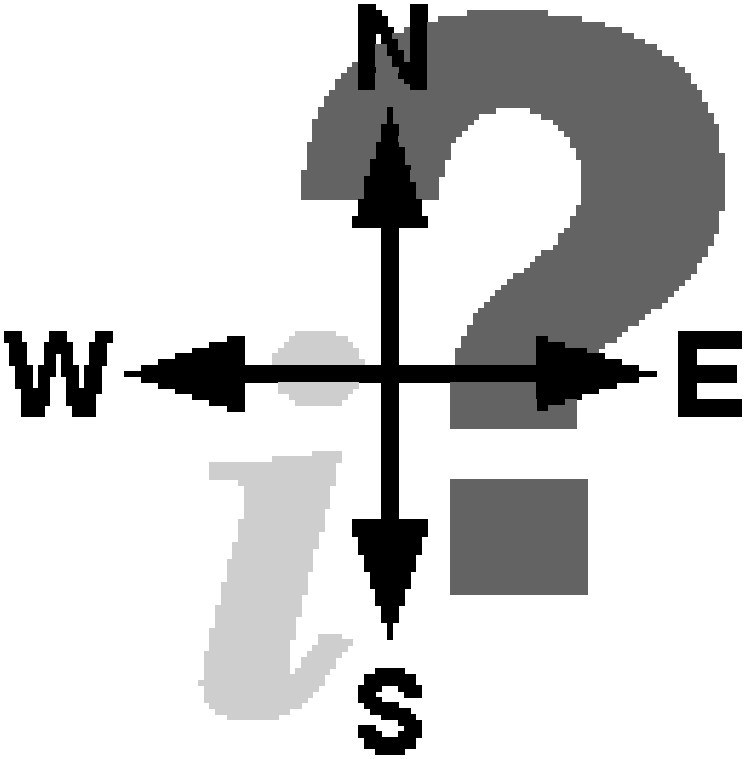
As-Built Drawings

* Configuration Management
* Subcontracts Opportunities
* Use as a component - not a solution



So Are You Ready?

1. Hazard Identification
2. Communication
3. Mitigation & Safeguards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Standard Interpretations

03/31/2004 - Fixed Wiring in Research Facilities and High Voltage Cable Tray Systems at Department of Energy (DOE) Research Laboratories

Standard Interpretations - Table of Contents

- **Standard Number:** 1910.305(a); 1910.305(a)(2); 1910.305(a)(2)(iii)(B); 1910.305(a)(3); 1910.305(b); 1910.305(g)(1); 1910.305(g)(1)(i); 1910.305(g)(1)(iii); 1910.399

March 31, 2004

MEMORANDUM FOR: RUTH MCCULLY
Director, Directorate of Science, Technology, and Medicine

FROM: RICHARD E. FAIRFAX, CIH, DIRECTOR
DIRECTORATE OF ENFORCEMENT PROGRAMS

SUBJECT: Fixed Wiring in Research Facilities and High-Voltage Cable Tray Systems at Department of Energy (DOE) Research Laboratories

Thank you for your March 4, 2004 memorandum regarding the compliance audits at the DOE research laboratories and our *Electrical*, Subpart S, standards contained in 29 CFR Part 1910. Your paraphrased questions and our replies follow:

Question 1: Six of the research laboratories have accelerators, which have substantial electrical requirements and are used for physics research. At times, when the accelerator is shut down, some of the wiring must be moved or changed; but wiring often may be in place for years. Also, with respect to other large research equipment, such as particle detectors, there are a large number of devices that are not hard-wired and instead use flexible cords equipped with attachment plugs. Typically, the equipment is upgraded to seek continually higher levels of performance, or, in some cases, items are inserted, tested, modified, removed, re-modified, reinstalled, etc. This occurs during *downtime* periods, where the accelerator is brought down and new equipment is installed. This may be over a period of months or years.

Your Directorate's October 12, 1995 interpretation letter, regarding flexible cord use for research projects, to the Department of Navy was reviewed, and it does not appear to address our situation.[1]

The impact of OSHA requiring fixed (permanent) wiring will have substantial financial implications for the DOE laboratories. What is the length of time or the criteria to determine when fixed (permanent) wiring is required in lieu of flexible wiring?

Reply: Both permanent wiring and temporary wiring may be either fixed (that is, fastened in place) or moveable (that is, connected by flexible cords or cables). Because your scenario involves the use of flexible cords, we explain when flexible cords or cables are permitted as a temporary wiring method and when they are permitted with permanent wiring.

29 CFR §1910.305(a)(2)(iii)(B) requires temporary branch circuits to be run as multiconductor cord or cable assemblies or as open conductors. Thus, flexible cords and cables are permitted

to be used as branch circuit conductors whenever temporary wiring is permitted and is actually being used. The *Temporary wiring* requirements, which are contained in §1910.305(a)(2), lists permitted uses for temporary wiring, permits temporary wiring of 600 volts or less to be used for experimental work, and permits temporary wiring of more than 600 volts to be used during periods of tests and experiments. No specific time limit, in terms of days, weeks, or months, has been established for temporary wiring used in experimental work. Rather, for this type of work, temporary wiring is only permitted during the duration of an experiment.

In your scenario, it appears that the accelerator and other referenced research equipment are permanently-installed, and the research laboratories have chosen not to temporarily install the accelerators, other large equipment, and their supply wiring. Rather, the research laboratories have selected a temporary wiring method and installed it permanently. The research equipment wiring remains in place for years; thus, the wiring is permanent wiring. It should be noted, however, that any wiring that is added to or removed from permanently-installed research equipment to accommodate the running of specific experiments can be run as temporary wiring. In contrast to the permanently-installed equipment, this wiring would be installed temporarily and would need to be removed when the experiments calling for its use are concluded.[2]

Even though the supply wiring for accelerators and other permanently-installed equipment must meet the requirements for permanent wiring methods, it may still be permissible to use flexible cords or cables. Paragraph (g)(1) of §1910.305 lists nine specific situations in which flexible cords may be used.[3] (Even in these situations, flexible cords and cables must be approved and suitable for the conditions of use and location.[4]) The following provides a partial listing of the circumstances in which flexible cords and cables may be permitted for use at a research laboratory. While §1910.305(g)(1)(i) lists several additional circumstances, those listed below are the most likely to be applicable at a research laboratory:

1. pendants (typically, a lampholder or cord-connector body suspended by a length of cord properly secured and terminated directly above the suspended device);
2. wiring of fixtures;
3. connection of portable lamps or appliances;
4. connection of stationary equipment to facilitate their frequent interchange; and
5. prevention of the transmission of noise or vibration (in some cases vibration may fatigue fixed wiring and result in a situation more hazardous than flexible cord).

Unless flexible cords and cables are specifically permitted for use in situations detailed in §1910.305(g)(1)(i), they must not be used. Furthermore, unless specifically permitted otherwise by any of the nine permitted conditions, §1910.305(g)(1)(iii) requires that flexible cords and cables may not be used:

1. as a **substitute** for the **fixed wiring** of a structure;
2. where run through holes in walls, ceiling, or floors;
3. where run through doorways, windows, or similar openings;
4. where attached to building surfaces; or
5. where concealed behind building walls, ceilings, or floors.

Question 2: What are the OSHA requirements for the type and quantity of cable (weight loading) for cable trays, including the cable spacing requirements?

Reply: The *Cable Trays* requirements, contained in §1910.305(a)(3), address the general installation and use requirements, including the types of cable permitted to be installed in cable tray systems. In terms of the quantity (fill requirements) and weight (load requirements) of cable(s) permitted in a tray and the spacing requirements between cables, these installation specifications would be determined through the instruction included in the listing or labeling associated with the particular cable tray system. As mentioned above, electrical equipment must be approved and suitable for the conditions of use and location and used/installed in accordance with general requirements for all conductors and equipment contained in §§1910.303(a) and (b).

This installation and use information should be included in the manufacturer's instructions.

Manufacturers typically incorporate recognized good engineering practice into their instructions, such as including references to the National Electrical Code (NEC) and National Electrical Manufacturers Association (NEMA) standards.[5]

In summary, the OSHA electrical standards require electrical equipment to be approved and used/installed in accordance with any instructions included in the listing or labeling. Manufacturers generally will provide this information on their product specifications to ensure that their equipment and conductors are installed and used in accordance with the listing and labeling requirements.

We hope you find this information helpful. If you have any further questions, please feel free to contact the Office of General Industry Enforcement at (202) 693-1850.

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[1] The Department of Navy letter synonymizes the terms *temporary wiring* and *flexible cords and cables* within the context of the response. As noted in the response below, these terms are not synonymous, and there are separate and distinct requirements for temporary wiring and flexible cords and cables, which are contained in §§1910.305(a)(2) and 1910.305(g), respectively. [back to text]

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[2] This is further clarified in the Section 527.3(D) of the 2002 National Electrical Code, which requires temporary wiring to be removed upon completion of the purpose for which the wiring was installed. [back to text]

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[3] There is a definite need and place for flexible cords, but there also may be a temptation to misuse them because they are perceived to offer a quick and easy way to carry electricity. The basic problem with flexible cords is that they generally are more vulnerable than fixed wiring. In many cases in which flexible cord is used, the protection associated with a recognized permanent wiring method is diminished. Flexible cords may be used only when permitted by the standard.

Furthermore, the provisions contained in the *Electrical Safety-Related Work Practices* standards contain important safety requirements regarding the safe use of cord- and plug-connected equipment, including flexible cord sets and extension cords. Specifically, some of the requirements contained in the *Use of equipment* paragraph, 1910.334(a), address common safe work practices for portable electric equipment. [back to text]

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[4] See §§1910.303(a) and (b) and §1910.305(g)(1) and also the definitions of *approved, acceptable, certified* and *listed* contained in 1910.399. [back to text]

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[5] For your information, the *Metal Cable Tray Systems (NEMA VE 1)* standard contains maximum allowable load specifications, and the *Cable Tray Installation Guidelines (NEMA VE 2)* require cable trays to be installed in accordance with the NEC. For example, section 392.6(E) of the NEC (2002) permits multiconductor cable rated at 600 volts or less (low-voltage) to be placed in the same cable tray. The high-voltage multiconductor cable requirements are contained in section 392.6(F), and high-voltage multiconductor cable is required to be 1) type MC (metal-clad cable) or 2) to be separated from low-voltage cable by a fixed barrier of a material compatible with the cable tray. [back to text]

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